SHEEP AND GOAT PRODUCTION IN THE NORTH WEST PROVINCE OF CAMEROON WITH SPECIAL REFERENCE TO PARASITIC GASTROENTERITIS

By

KENNETH JACOB NGOH NDAMUKONG

B.Sc. (Ife), M.Sc. (Ife)

A thesis presented for the degree of
Doctor of Philosophy
University of Edinburgh
1987

CONTENTS

ABBREVIATIONS AND SYMBOLS

ad lib.	*ad libitum*
Ag., Aug.	August
A/G ratio	Albumin/Globulin ratio
Ap., Apr.	April
B	Bucks
BCG	Bromocresol green
bld	blood
B. trigono.	*Bunostomum trigonocephalum*
B. trigo.	
CAM	Cellulose acetate membrane
CCPP	contagius caprine pleuropneumonia
Co.	Company
Conc.	concentration
CTVM	Centre for Tropical Veterinary Medicine
Cum.	cumulative
D	Does
D., Dec.	December
DM	Dry matter
E	Ewes
EK	European kid
EL	European lamb
ES	Moredun sheep-adapted strain
etc.	et cetera
F., Feb.	February
FAO	Food and Agricultural Organisation
Fen	Fenbendazole
Fig.	Figure
fl	femtolitres
g	gramme
g/dl	gramme/decilitre
Haem.	*Haemonchus*
Hb	haemoglobin
Hb conc.	haemoglobin concentration
H.c.	*Haemonchus* contortus
i.e.	that is
ILCA	International Livestock Centre for Africa
increm.	increment
IRZ	Institute of Animal Research
J., Jan.	January
Jl., Jul.	July
Jn., Jun	June
K	Kids
kg	kilogram
L	Lambs
L_1	First larval stage of nematode
L_3	Third larval stage of nematode (infective stage and first parasitic stage)
L_4	Fourth larval stage of nematode (second parasitic stage)
L_5	Fifth stage (adult worm)
LC_{50}	concentration giving 50 percent mortality
LC_{100}	concentration giving 100 percent mortality

Lev.	levamisole
ld-p	Log dose-probit
LG	Mankon goat-adapted strain
LS	Mankon sheep-adapted strain
lsd	least significant difference
Ltd.	Limited
M	molar
Mar., Mr.	March
Max	maximum
M & B	May and Baker
MCH	Mean corpuscular haemoglobin
MCHC	Mean corpuscular haemoglobin concentration
MCV	Mean corpuscular volume
Min.	minimum
ml	millilitre

mm	millimetre
mU	milliunit
Mx	Mixed grazing
My	May
N., Nov.	November
nm	nanometre
No.	Number
N.W.	North West
O., Oct.	October
O.c.	*Ostertagia circumcincta*
O. columb.	*Oesophagostumum columbianum*
Oesoph., Oes.	*Oesophagostomum*
P	Probability
PCARR	Philippine Council for Agriculture and Resources Research
PCV	Packed cell volume
pg	picogrammes
PPR	*Peste des petits* ruminants
R	Rams
r	correlation coefficient
RBC	Red blood cell
Red.	reduced
RF	resistance factor
rpm	revolutions per minute
S., Sep.	September
SD	standard deviation
SG	specific gravity
S. papill.	*Strongyloides papillosus*
Stand.	standard
T. col.	*Trichostrongylus colubriformis*
T. colubr.	
Trich.	*Trichostrongylus*
Tricho.	
Trichu. ovis	*Trichuris ovis*
TS	On-station traditional management
TVM	Traditional village management
WBC	White blood cell
%	percent
µm	micron, one millionth of a metre
µl	microlitre, one millionth of a litre
>	greater than
<	less than
4-D	4-dose anthelmintic regime
2-D	2-dose anthelmintic regime

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF FIGURES

LIST OF PLATES

ACKNOWLEDGEMENTS

The successful realization of this research project could not have been possible without earnest contributions from many friends and relatives. My most sincere gratitude goes to my supervisor, Dr. M.M.H. Sewell, for initiating my interest in this research topic and for his expert supervision throughout the study. His invaluable comments on my monthly research reports coupled with his visits to Cameroon during the course of the study largely contributed to the success of the work. I am also indebted to him for patiently reading through the manuscript and making very helpful comments and suggestions. My local supervisor, Dr. Moses Asanji, was of immense assistance through his encouragement and close collaboration and I wish to express my deep appreciation to him.

I acknowledge, with deep gratitude, the sincere contribution of Mr. Harry Urquhart of the CTVM towards the realization of this research work. His promptness in providing solutions to some of the technical problems I encountered in the course of the research is greatly appreciated.

My thanks go also to Dr. R.L. Coop of Moredun Research Institute, Edinburgh, for his collaboration and assistance in supplying the ES strain of *Haemonchus contortus* used in the experimental studies.

I would like to thank very sincerely Pa L.M. Ndamukong, Godlove Mba, John Mba and Godlive Akoh, the farmers at Batibo who allowed me access to their animals throughout the two years of epidemiological studies. I am grateful to Miss Yvette Wood of CTVM and to Samuel Chi, Acha Daniel, Samuel Oteh, Samuel Njong and Michael Che of I.R.Z. Mankon for ably looking after the experimental animals. John Tamufor and occasionally also Drs. D. Awah and A. Nfi assisted me with blood collection and I am grateful to them.

Most of the burden of the laboratory analyses rested on Divine Fomunyam, Daniel Fongwe, Kevin Acha and Gabriel Ndjomegni to whom I owe a real debt. Also John Mofor, Esther Ntumngia and Henrietta Amabo assisted at various times. Tom Landji carried out prompt maintenance work on the laboratory equipment. Wilfred Ndamukong was largely responsible for tracing out the graphs. The histological slides were prepared at the CTVM by Neil MacIntyre, Gary McQuade and George Randall. To all of them, I extend my very profound gratitude. I am greatly indebted to Mr. Alan Rowland for his assistance with the interpretation of the histological slides, to Mr. Bob Munro

for the photographic services, to Dr. G. Keay for helping with the determination of the electrophoretic values of the differential serum proteins and to Dr. G.R. Scott for assisting with statistical analyses.

Mrs. H. London, Miss Judith Anderson and Mrs. Susan Smyth, the librarians at the Veterinary Field Station and the CTVM, were of immense assistance in locating the relevant literature information I needed. Mrs. Rosemary Dowell and Mr. T.R. Melrose provided very efficient technical services.

I would like to express my indebtedness to Professor D.W. Brocklesby, Director of the Centre for Tropical Veterinary Medicine, for providing me with the facilities to carry out my research work at the Centre. I attribute the successful completion of this research work to Dr. E.D. Tebong, Director of the Institute of Animal Research in Cameroon, who gave me all the encouragement and necessary assistance to guarantee my success. I lack the words to express my gratitude to him. My thanks are extended to Dr. R.T. Fomunyam, Chief of the Animal Research Station at Mankon, for her collaboration and encouragement, to Miss F. Anne, Director of the Nursing School Cycle C, for allowing me access to her laboratory facilities and to Mr. Joseph Ncho of ADU BROS for his promptness in supplying some of the equipment and chemicals.

I deeply appreciate the moral support given to me by all my colleagues at I.R.Z. Mankon Station and by Dr. Leslie Harrison, Mrs. E. Moore and the entire staff of the CTVM.

This work could not have been achieved without family love and sacrifice. My wife, Patricia, and children regularly rendered a helping hand, and kept me company through the long hours I often had to spend in the laboratory. My wife's continuous encouragement and personal sacrifices greatly eased the burden of the work. I am indebted to my entire family for accepting the challenge and ably standing firmly behind me throughout the tedious years of this research.

Finally I owe a real debt to Mrs. Carol Dickson for expertly typing the thesis. Financial assistance for the first year of the research was provided by the British Council and in all subsequent years by the Cameroon Government and I am most grateful.

DECLARATION

The work described in this thesis is original and has not been submitted in any form to any other University. It was carried out partly in Cameroon and partly at the Centre for Tropical Veterinary Medicine, University of Edinburgh, under the supervision of Dr. M.M.H. Sewell, assisted in Cameroon by Dr. Moses Asanji.

SUMMARY

A research project was carried out between October 1983 and June 1987 partly in Scotland and partly in Cameroon covering three main areas: a survey on small ruminant production and epidemiological and experimental studies on parasitic gastroenteritis in these animals.

The survey on traditional management of sheep and goats was conducted in North West Province of Cameroon using a questionnaire. The main objectives were to assess the productivity, to identify production constraints and to propose possible solutions. Sixty-five farmers in Mezam division and 50 in Momo division were interviewed. The results showed that 92% of the farmers rear goats as against only 21% who rear sheep. A traditional belief by which sheep keeping adversely affects a woman's fertility is perhaps the greatest constraint on sheep production. Flock sizes are small, typically 6-7 animals in single species flocks and up to 12 animals in mixed flocks. Females make up 88% and 84% of sheep and goat flocks respectively with 62% and 58% of the total sheep and goat flocks being breeding females over 12 months of age.

Six management systems were identified. Those involving tethering during the cropping season and either tethering or semi-extensive grazing in the non-cropping season are most widely practised. The most common housing system is an enclosed shed with walls of sticks, tree fern or bamboo. Floors of planks laid on the earth or slightly raised are used by about 48% of the farmers while only 22% construct raised slatted floors.

Intentional feed supplementation is rare but salt is given by most farmers on a more or less regular basis. Watering was not considered essential by about 47% of the farmers.

Breeding is generally uncontrolled and progeny of the most active breeding ram/buck is often the main source of ram/buck replacement; therefore inbreeding is common.

Offtake rates were 20% and 24% in sheep and goats with flock mean percentages of 26% and 23% respectively. The highest offtake rates were recorded under tethering/semi-extensive (35% and 28% for sheep and goats respectively) and extensive/extensive (48% for sheep).

Mortality rates were not significantly different in either young animals (17% and 14% in lambs and kids respectively) or adults (17% and 11% in adult sheep and goats respectively). There was some suggestion of higher mortality rates under semi-intensive/semi-intensive and semi-intensive/semi-extensive management systems. Tick infestation and diarrhoea were considered to be among the major causes of death. Five disease problems of small ruminants were identified on the basis of the signs reported by the farmers: intestinal parasitism especially helminthiasis, tick infestation and the viral diseases associated with it, pneumonia, peste des petits ruminants and *Oestrus ovis* infestation. Traditional medicine for treatment of sick animals is practised on a very small scale with very limited success.

A survey on haemoglobin types was carried out on sheep and goats collected from the North West Province and Northern Cameroon as background studies to the experimental work on haemonchosis. Three adult haemoglobin variants (HbA, HbB and HbC) were identified. Haemoglobin types A and B occurred in sheep and haemoglobin types B and C in goats. The gene frequencies of the A and B alleles were 0.08 and 1.00 in Grassland Dwarf sheep and 0.06 and 1.00 in Fulani Bornu sheep. In the goats the gene frequencies of the B and C alleles were 1.00 and 0.15 in Grassland Dwarf goats and 1.00 and 0.38 in Red Sokoto goats. Abnormal production of a haemoglobin with similar electrophoretic mobility to Hb type C was observed in both species under haematological stress. The intense selection of the B gene in the sheep and goat population is of potential interest.

The epidemiological studies were intended both to examine the factors which predispose sheep and goats to helminth infections and their effects on production, and to evaluate the efficiency of various control measures intended to increase production. The regime of monthly deworming with fenbendazole currently practised at the research station was used as the control for the first year's epidemiological study designed to investigate the effect of reducing the frequency of such treatment on the survival and productivity of small ruminants. Three management systems were compared: the control regime, a regime involving five strategic treatments and

traditional village management with no anthelmintic. The performance of the animals was monitored for one year. At Mankon the goats gained less weight than the sheep. On the contrary the traditionally managed goats both survived better and gained more weight than traditionally managed sheep.

The strongyle faecal egg counts from both sheep and goats fell at the start of the dry season and remained low until April regardless of the system of management or the frequency of anthelmintic treatment. Pasture larval counts and infection levels in tracer animals were low during this period. During the rainy season faecal egg counts were consistently lower in sheep at Mankon than in goats while in the village animals the reverse was the case. In the animals at Mankon, egg counts made 15 days after treatment were similar to the pretreatment counts. The possibility of benzimidazole resistance by the trichostrongyles in the animals at Mankon was suspected and confirmed by conducting egg counts one week after treatment and by an *in vitro* anthelmintic sensitivity test in which it was shown that strongyle eggs from the animals at Mankon consistently developed in higher concentrations of tiabendazole than eggs obtained from the village animals.

Pasture larval counts were high during the rainy season producing two waves of larval contamination on the pastures, one in mid-June and the other towards the end of the rains in November. The period of maximum infection in tracer animals followed the June peak of pasture contamination. High mortality in traditionally managed sheep in July, August and September also coincided with periods of heavy larval challenge. *Haemonchus contortus*, *Trichostrongylus axei*, *Trichostrongylus colubriformis* and, to a lesser extent, *Moniezia expansa* were prevalent throughout the year but with larger numbers present during the rainy season. *Oesophagostomum columbianum* and *Bunostomum trigonocephalum* were prevalent mainly during the rainy season, heavy burdens in the animals dying during the dry season apparently having been acquired in the late rains.

The primary haematological parameters (PCV, Hb concentration and RBC counts) in the animals at Mankon tended to be low during the dry season but increased at the onset of the rains

and changed very little thereafter. However, in the traditionally managed sheep, the values of these parameters tended to decline overall. In general the haematological values were somewhat lower in the animals on the reduced regime than in those on the standard regime, and in the traditionally managed sheep and goats than in those at the research station.

In the animals at Mankon, the serum total protein and albumin concentrations were low during the dry season. In sheep the total protein increased significantly at the beginning of the rains while the albumin changed very little throughout the year. In goats the albumin concentration showed a more or less steady fall throughout the study. In all animals the globulin values were generally elevated during the rainy season. Serum pepsinogen levels were low during the dry season but increased during the rainy season. In the traditionally managed animals the serum biochemistry did not change significantly throughout the study.

The second year of the epidemiological study examined the possibility of further reducing the frequency of anthelmintic treatment when an effective anthelmintic is used. The experimental groups received either four or two strategically timed anthelmintic doses, the traditionally managed group included an on-station simulation study and a group of sheep and goats were kept together on mixed grazing.

In this year the survival rate was significantly higher in sheep than in goats under all management systems except in those on traditional management.

The faecal egg count patterns in all the groups during the dry season were similar to the previous year. Following anthelmintic treatment in the 4-dose group with levamisole in early March, the faecal egg counts were initially reduced to zero in both sheep and goats. Under both the 4-dose and 2-dose regimes treatment with levamisole maintained egg counts in all animals at less than 200 epg throughout the rainy season. Nevertheless the goats at Mankon still carried slightly higher egg counts than sheep. Traditionally managed animals again showed higher egg counts in sheep than in goats.

Although the peak periods of pasture larval contamination were modified by the anthelmintic treatments, the overall pattern of

seasonal availability of trichostrongyles remained unchanged.

Sheep maintained higher PCV values than goats throughout the year. There was a similarity in the serum protein patterns in all groups in both hosts with a tendency for the albumin levels to remain fairly constant and for the globulin levels - and hence the total protein - to fall or remain static during the dry season and then to rise during the rainy season. No consistent differences were found between age or treatment groups but some of the changes with time were significant.

The albumin values determined by the bromocresol green method were consistently and significantly lower in goats and higher in sheep than those determined by electrophoresis.

The experimental studies largely reflected and amplified the epidemiological findings. The development of the parasite and its relationship to haematological, biochemical and pathological changes were studied in lambs and kids after a single infection of 10,000 L_3 of *Haemonchus contortus*. In Scotland using a local sheep-adapted strain (ES) and European lambs and kids, the PCV and Hb concentration in the lambs declined rapidly from day 10 after infection whereas in kids this was less marked and there was an initial rise in these values during the first three days following infection. Localized areas of mucosal hypertrophy were visible on the abomasal surface by day 4 and a coagulum covered the fundic abomasal surface on day 8 in both lambs and kids and on day 14 in the kids only. There was a steady reduction in the number of worms recovered with age of the infection, more dramatic in kids than in lambs. The infections were accompanied by mucosal hypertrophy and infiltration of lymphoid-type cells, plasma cells and eosinophils. Desquamation of the mucosal epithelium was visible from day 8.

The single infection studies at Mankon compared the response of indigenous lambs and kids to infection with three strains of *Haemonchus contortus*, two derived from local goats (LG) and sheep (LS) respectively and one ES strain. The primary haematological parameters were more severely lowered in kids than in lambs for at least 12 days after infection. The depression was more severe in animals infected with the LS strain than in those infected with the LG or ES strains. The changes in serum protein

biochemistry were less marked but with an overall tendency for the total protein and albumin to fall after day 12 in animals infected with the LG and LS strains. Female worms in both hosts were clearly larger than the male worms from day 8 and the worms from the lambs were clearly much bigger than those from the kids from day 11. Sexual maturation was reached earlier in the worms from the lambs than in those from the kids. The pathological changes were similar to those seen in the infections in Scotland. However, the coagulum was observed in kids infected with the LG and LS strains killed on days 8, 11 and 14 whereas in lambs it was observed only in those killed on day 11. No signs of gastric haemorrhage were observed in any of the indigenous animals infected with the ES strain. Overall the severity of the parasitic effects was greater in kids than in lambs and in animals infected with the two local strains than in those infected with the ES strain.

The epidemiological pattern observed in temperate countries at the end of the winter was simulated by an escalating infection study. European lambs and kids were infected with increasing doses of *H. contortus* (ES strain) twice weekly for five weeks. Results showed depressed liveweights in lambs from six weeks onwards. Anaemia developed in the course of the infection, being more severe in the lambs than in the kids. Serum total protein and albumin dropped significantly in the lambs while the changes in kids were not significant. Serum pepsinogen concentration rose during the infections, the rise being more consistent in the kids. Lambs had significantly more worms, a shorter prepatent period and higher faecal egg counts than kids.

The daily infection of indigenous lambs and kids in Cameroon with small doses of the two local strains of *Haemonchus contortus* was intended to simulate a field situation in which animals are grazing continuously on lightly contaminated pastures. The results showed that there was considerable reduction in liveweight of the kids compared to the controls whereas the growth of the lambs was not affected. Most of the higher faecal egg counts in kids were in animals infected with the LG strain whereas in lambs it was the LS strain that gave rise to the highest counts. However, throughout the 20 weeks of the study most animals had less than 500 epg in their

faeces. Necropsy worm counts revealed that kids carried higher burdens of the LG strain and lower burdens of the LS strain than lambs, but the counts in all cases were generally less than 600 per animal. There was a prolonged depression of the primary haematological values in kids infected with both strains of *H. contortus* whereas these values in lambs fluctuated within the pre-infection range. Serum protein biochemistry did not change significantly while serum pepsinogen levels increased in the course of the infection.

It was concluded that a management regime utilizing three strategic anthelmintic treatments under set-stocking conditions is indicated for controlling parasitic gastroenteritis in sheep and goats kept on the research station in the North West Provice of Cameroon. In the villages treatment, especially of sheep, during the rains may be beneficial and cost-effective.

GENERAL

INTRODUCTION

In 1985 the small ruminant population in Cameroon was estimated at 3,830,000 (1,900,000 sheep and 1,930,000 goats); this is much less than the 1979-81 estimate which stood at 4,423,000 (2,167,000 sheep and 2,256,000 goats) (FAO, 1985). Thus even though small ruminants constitute a major source of animal protein as well as a flexible source of income for the rural population, production seems to be on the decline. The cause(s) of this declining production can be ascertained by reviewing the production patterns of these animals in the developing countries and Cameroon in particular.

Sheep and goat production in the developing countries like Cameroon is largely in the hands of small-scale subsistence farmers in rural areas. In the humid part of West Africa most families keep small ruminants, the average number per owner being only three or four animals, with goats predominating. Indeed in some villages there are no sheep (ILCA, 1979). As most of these farmers are also crop farmers or are occupied with other off-farm work, the animals are largely left to fend for themselves. They feed mostly on natural vegetation plus scraps of household waste which have not been deliberately fed to them. There is no control of breeding and the animals receive virtually no veterinary care. Because of poor management and feeding, coupled with lack of any breeding programme, the full potential of these animals cannot be realised. The result is poor productivity as a result of poor growth rate and high mortality.

Most of the research work with West African Dwarf goats and sheep has taken place on experimental stations. Comparatively little research has concentrated on describing the current village production systems or evaluating modifications in village systems *in situ* (Sumberg and Cassaday, 1985). Peters et al. (1981) defined five systems of management of goats and sheep:-

Intensive: The animals are permanently confined to a shed. This system involves a cut and carry feeding system. Animals are protected from extremes of environmental influence.

Semi-intensive: The animals are let out for grazing within a restricted period of time mainly in the afternoon and then confined at night and part of the day.

Tethering: The animals are kept in a shed during the night time whereas during the day they are tethered along the road side, on public grounds or in the vicinity of the house. Female and male animals and the different age groups are not separated when in the shed.

Semi-extensive: The animals are kept in the shed during the night and let out for grazing on free range during the late morning hours. They may return to the shed on their own or are taken back by somebody.

Extensive: The animals are kept on free range both during the day and night. Hence they are entirely exposed to the external environmental conditions.

Devendra (1976) recognised as another system of goat and sheep production the integration with cropping system. Haenlein and Devendra (1983) saw the advantages of integration as being increased fertility of the land due to the return of dung and urine, reduced fertilizer wastage, control of waste herbage growth, easier management of the parent crops and distinct possibilities of increased crop yields and greater economic returns. Unfortunately small ruminant keeping is generally not integrated with crop production as no forage crops are grown and manure is not returned to the cultivated plots.

The intensive system (stall feeding) demands continuous management of the animals and requires the availability of abundant supplies of agro-industrial by-product feeds and/or cultivated grasses fed *in situ*. It requires a high labour and cash input. Semi-intensive management also requires the availability of such fodder to supplement the intake from pasture. Confinement of animals increases disease risks with higher mortality than is evident among free roaming animals. Extensive and tethering systems embrace the traditional village system typical in Africa, parts of central America and South-east Asia (Devendra, 1981). In the extensive systems, the animals browse and scavenge on what feeds are immediately available near the farm and households. The

animals are free roaming. Vegetation is often more or less strongly degraded and the most preferred feeding plants are reduced (Gall and Huhn, 1981). Effective measures to control epidemics or breeding are nearly impossible.

Devendra (1981) associated low productivity of sheep and goats in Africa with the extensive system of managing them. When these animals are free roaming, there is little management or capital input. Few animals receive veterinary care and hence mortality especially within the first three months after birth is high (Sumberg, 1985). As breeding is not controlled, early conception in immature females is common and may contribute to high kid/lamb mortality (Mack et al., 1985). Moreover the chances of inbreeding occurring are increased. Uncontrolled breeding and inbreeding are important limitations on a high rate of reproduction.

Upton (1985) identified the major direct constraints on the productive performance of livestock as breeding, nutrition, health, management and marketing. The order of importance for sheep throughout the tropics is probably nutrition, disease, management, breeding and marketing (Devendra and McLeroy, 1982). Productivity can only be improved through improvements in husbandry practices, management, organised breeding and disease control.

Nutrition: Devendra (1981) regards nutrition as the most important environmental factor influencing liveweight at slaughter, hot carcase weight, dressing percentage and weight of meat, total saleable weight and total edible weight. Measures for improvement of feed production must include establishment of productive permanent fodder crops like legumes (Gall and Huhn, 1981). Mixed grazing can lead to better utilization of the pastures. While sheep and cattle prefer grasses and eat these almost exclusively, goats prefer browse and herbs, obtaining about 50% of their nutritional requirements from tree and bush vegetation (Gall and Huhn, 1981; Peters and Horst, 1981). Improvements in feeding could contribute to a full exploitation of production performance and greatly increase growth rate of indigenous animals. Irrespective of the system of management, feeding hay and silage can considerably improve livestock feeding in the dry season and thereby reduce losses from starvation.

Breeding: If production has to increase, there must be purposeful selection and breeding of the indigenous breeds as this would lead to genetic upgrading (Devendra, 1981). Gall and Huhn (1981) suggested that the age of young goats (and sheep) at first parturition must be adapted to the intensity of the feeding in order to prevent reduction in production caused by straining undeveloped goats (and sheep) too early and, on the other hand, in order to extend the span of productive life. PCARR (1977) recommends that to prevent in breeding, breeding bucks should be changed every two years or bucks can be exchanged on a private basis. Sexes should be separated, unwanted males should be castrated early.

Diseases and intervention: Disease is one of the main constraints in sheep and goat production in the least developed countries (Devendra, 1981) and seriously limits their production in humid and subhumid zones (Gatenby, 1982). The incidence of diseases, pattern of transmission and spreading, pathogenesis, prophylactic measures and methods of treatment as well as economic implications of many diseases and epidemics of small ruminants have been insufficiently researched (Gall and Huhn, 1981). This holds true for resistance, tolerance and naturally acquired immunity or premunition of indigenous goat/sheep populations to particular endemic diseases. Veterinary care in developing countries has almost without exception been limited to the health care of cattle stock (Gall and Huhn, 1981).

Studies carried out by Peters et al. (1981) in West Malaysia identified seven diseases of goats: bloat and contagious ecthyma being the most common, followed in declining order by mange, endoparasites, diarrhoea, pneumonia and foot rot. They observed that in general disease conditions occurred less often under intensive conditions than in the semi-intensive and semi-extensive systems. Mange and contagious ecthyma followed by endoparasites were disease problems mentioned most frequently for the semi-intensive system. Chiejina (1986) observed in Nigeria that sheep and goats kept on modern farms (that is under semi-intensive management as on government farms and research stations) were frequently exposed to heavy worm infections especially during the rainy season as a result of overstocking, poor grazing management

and the absence of effective deworming and control programmes. Traditionally managed small ruminants which are free roaming are unlikely to encounter heavy worm infestations since faecal contamination is spread over a relatively large area. However, tethering during the rainy season (cropping season) restricts their grazing area and quickly leads to a build-up of contamination on pasture and may possibly lead to an outbreak of parasitic gastroenteritis but more often the infection remains subclinical and chronic in nature. Mack (1982) and Adeoye (1985) recognised *peste des petits* ruminants (PPR) and sarcoptic mange (*Sarcoptes scabiei*) as the major causes of morbidity and mortality, particularly among the roaming goats, in south-west Nigeria. Among goats treated against PPR and mange, helminthiasis, babesiosis and coccidiosis were the only diseases diagnosed as causing mortalities of which helminthiasis caused 47%, babesiosis 12% and coccidiosis 6% of all mortalities (Adeoye, 1985). Sheep were less susceptible to potentially acute diseases (PPR, pneumonia, trypanosomiasis and helminthiasis) than goats. Apart from the aforementioned diseases, other diseases constraining the productivity of village flocks are contagious caprine pleuropneumonia (CCPP), hydatid cysts on lungs and liver, anthrax, brucellosis, foot and mouth disease, blue-tongue, sheep and goat pox and clostridial diseases etc.

Devendra (1981) remarked that the most severe effects of disease and parasites in adult sheep and goats in the developing countries are manifested in production losses including fertility, these effects being due to nutrition stress, debilitation and internal parasites. In Africa, African folk medicine has been used against goat and sheep diseases: bark of various trees and from roots, leaves and flowers of numerous plants (Heinz, 1982). The need for vigorous research on animal diseases as a potential means of increasing productivity from sheep and goats has been emphasised (Devendra, 1981). Disease control programmes may reduce mortalities and thereby expand productivity with little change in farming systems (Upton, 1985). Epizootiological surveys are necessary in every location in order to develop economical and effective preventive and control programmes for each location, to be applied in cooperation with extension services (Gall and Huhn, 1981).

PART I

LITERATURE REVIEW

The adverse effects of parasites, especially helminths, on animal production and health have been emphasized (Srivastava, 1938; Doll and Hull, 1944; Gordon, 1958a; Spedding, 1962; Becklund, 1964; Brunsdon, 1965, 1966; Schillhorn van Veen, 1973; Herlich, 1978; Akerejola *et al.*, 1979; Leyva *et al.*, 1982). Losses in production are incurred mainly through reduced liveweight gains, decreased quality and quantity of wool and increased mortality. Parasites have been shown to decrease significantly the apparent digestibility of feed, to reduce voluntary food intake even when the level of infestation is low, and adversely to affect mineral metabolism and vitamin intake (Steward, 1933; Franklin *et al.*, 1946; Gordon, 1950; Spedding, 1954; Gibson, 1955, 1963; Shumard *et al.*, 1957). Furthermore, they render the animal less resistant to various infections (Clarke, 1963). In addition to the direct effects on health and production and mortality rate, much of the loss accrues from the cost of anthelmintics and the extra labour expended in tending unthrifty animals.

Helminthiasis is a major parasite disease problem of sheep and goats in the tropics. FAO (1965), Kuil (1970) and Schillhorn van Veen (1973) grade helminthiasis as one of the most important diseases of small ruminants in Nigeria. Haemonchosis alone may account for losses of up to 40% in lambs (Akerejola *et al.*, 1979). The gastro- intestinal helminth parasites produce their ill effects through an inflammatory condition of the alimentary tract referred to as gastroenteritis. Gastritis is an inflammation of the stomach (abomasum) and is commonly associated with enteritis in the syndrome of gastroenteritis. Enteritis which is an inflammation of the intestinal mucosa in many instances occurs coincidentally with gastritis.

Parasites causing abomasitis in sheep, goats and cattle include *Trichostrongylus axei*, *Ostertagia* spp. and *Haemonchus* spp. Also heavy infestation with larval paramphistomes migrating to the rumen may cause abomasitis. Helminths causing enteritis in ruminants include *Strongyloides* spp., *Oesophagostomum* spp., *Trichostrongylus* spp., *Cooperia* spp., *Chabertia* spp. and *Nematodirus* spp. Occasional causes of enteritis include hookworms

(*Bunostomum* spp.), heavy infestation with tapeworm (*Moniezia* spp.) and stomach flukes (*Paramphistomum* spp.).

Parasitic gastroenteritis is actually a disease syndrome involving different effects of different species of helminths occupying different regions of the alimentary tract. Gordon (1950) suggested that the different symptoms produced by the different species provide indications for a different diagnosis and a subdivision of parasitic gastroenteritis into more or less specific diseases.

The severity of the effects of parasitism bears some relation to the number of parasites present and this population of parasites, which reproduce but do not multiply within the host, must be related to the number of infective larvae ingested during grazing (Spedding *et al.*, 1964).

Effect of climate on preparasitic stages

Infective larvae develop from eggs passed onto pasture in the faeces of the host. The parasite population in lambs or on pasture is affected by moisture level (Crofton, 1948) and temperature (Rogers, 1940). Temperature and moisture are of great importance in controlling the rate of development and survival of the free living stages of nematodes.

Moisture: It is clear that the preparasitic stages have a very high moisture requirement for full development. Research on *Trichostrongylus colubriformis* and *Haemonchus contortus* has shown that while *H. contortus* has only one desiccation-resistant stage, the ensheathed L_3 *T. colubriformis* has two:- larvated eggs (i.e. the fully developed L_1 inside the egg shell) and the ensheathed L_3 (Anderson and Levine, 1968; Waller and Donald, 1970; Dunn, 1978). Infective larvae of *Nematodirus* spp., *Cooperia oncophora* and possibly *Ostertagia* spp. are quite resistant to desiccation whereas *Strongyloides papillosus* would die within 24 hours under arid conditions (Wertejule, 1959). Cameron (1923) demonstrated that eggs and larvae of *Bunostomum* did not withstand desiccation for more than a few days, an observation confirmed by Belle (1959). Other species fall between these two extremes in their ability to withstand desiccation (Kates, 1965).

Available evidence suggests rainfall is a major determinant of the availability and transmission of strongylid nematodes of small

ruminants in the Northern Guinea savanna zone of Nigeria (Ogunsusi, 1979) and the forest zone of Western Nigeria (Okon and Enyenihi, 1975, 1977). Sprent (1946) demonstrated at Vom (Northern Guinea savanna zone) that the development and survival of preparasitic stages of *Bunostomum phlebotomum* of cattle are possible only during the wet season. Lee *et al.* (1960) working in the same climatic zone obtained similar results with regard to *H. contortus*, *T. axei*, *T. colubriformis*, *C. pectinata*, *C. punctata*, *O. radiatum* and *O. phlebotomum* and concluded that only negligible infestations are acquired during the dry season.

Infective larvae require moisture in which to migrate from soil and faeces to the herbage (Rogers, 1940; Crofton, 1948). Larvae move onto and up blades of grass in an entirely random fashion following water film pathways in the soil, humus, mat and vegetation (Crofton, 1954). Thus adequate rainfall and a pasture that maintains a micro-environment with sufficient humidity and aqueous condition are essential for larvae to move from faeces onto the stem and leaves of forage plants.

Temperature: Under conditions of moderate relative humidity and sufficient aeration, temperature constitutes the main environmental factor determining whether eggs of nematodes voided in faeces will develop to infective third stage larvae. Ransom (1906) observed that at an average of 10°C (fluctuating between 7.8 and 14°C) 3-4 weeks were necessary for development of eggs of *Haemonchus contortus* to infective stage, the duration being shortened to 6-14 days at 21°C. Veglia (1915) showed that between 15°C and 35°C infective larvae of *H. contortus* were produced within 3-8 days, the time required decreasing with increasing temperature. There was no marked variation in development time between 22°C and 35°C. Berberian and Mizelle (1957) found the development range of *H. contortus* to extend from a minimum of 12°C when only 1% of the larvae reached infective stage after 16 days of incubation to a maximum of 37°C when development took 5.5 days. They considered 33°C as the optimum temperature for development and survival, development taking only 2.5 days. Silverman and Campbell (1959) observed that under conditions of adequate moisture and aeration, freshly passed *H. contortus* eggs required five days at

21.7°C to reach infective larval stage, nine days at 14.4°C and 15 days at 11°C. Conway (1964) provided evidence that *H. contortus* eggs can develop in appreciable numbers at temperatures below 18.4°C. Crofton (1965) found 9°C to be the minimum temperature requirement for *H. contortus* eggs to hatch. Kates (1965) considered the temperature range for maximum *H. contortus* production to be 20–27°C. Narain and Chaudhry (1971) observed that eggs of *H. contortus* hatched in the laboratory at temperatures from 10°C to 37°C but only larvae hatching at 15°C to 37°C were able to reach infective larvae, requiring four days at 37°C and eight days at 15°C. No significant size variation of infective larvae was observed at different temperatures. Jehan and Gupta (1974) similarly reported that ova hatched and infective larvae developed at temperatures ranging from 10°C to 37°C, the eggs requiring 72 to 90 hours at 37°C and 312 to 360 hours at 10°C to become infective larvae. They considered 30°C to be the optimum temperature for free living stages. The above observations which confirm development to infective larvae being possible at temperatures as low as 10°C disprove the observations of Shorb (1943, 1944), Mizelle and Berberian (1953) and Dinaburg (1944) who respectively considered 13°C, 14.4°C and 18.3°C to be the minimum temperatures for production of third stage larvae of *H. contortus*.

The rate of development of eggs of *Ostertagia circumcincta* has also been found to increase with increasing temperature (Furman, 1944). Hatching can occur at temperatures as low as 4°C but 34°C is the upper limit recorded (Crofton, 1965), hatching occurring in 17 hours at 34°C and seven days at 6°C. Kates (1965) considered 14–22°C as the temperature range for maximum larval production. Young *et al.* (1980) studied the distribution of times of hatching of eggs of *O. circumcincta*. They found that below 6°C hatching of eggs was extremely variable. Between 6°C and 20°C the distribution of times of hatching of eggs incubated at these temperatures was approximately sigmoid in sheep. Salih and Grainger (1982) determined the rates of development of *O. circumcincta* eggs over a range of constant temperatures and concluded that eggs hatched at all temperatures between 5°C and 35°C, the duration increasing with decreasing temperature. Above

25–30°C the rate of development slowed down.

Belle (1959) gave the following times for development of *Bunostomum* to infective stage: 4–5 days at 25–35°C, 5–7 days at 20°C, 8–10 days at 15°C. He observed that *Bunostomum* will not complete its prepatent development below 15°C.

Preliminary observations by Silverman and Campbell (1959) with eggs of *Ostertagia* spp., *Trichostrongylus* spp. and *Oesophagostomum venulosum* showed that these species develop at a slower rate than *H. contortus* but they have a greater resistance to cold and desiccation than *H. contortus*. Eggs of *Chabertia* spp., *Ostertagia* spp. and *Haemonchus* spp. hatch at lower temperatures than those of *Cooperia* and *Bunostomum* while *Trichostrongylus* spp. falls between low and high temperature groups (Berberian and Mizelle, 1957; Silverman and Campbell, 1959; Crofton, 1963). The temperature range for optimum development of most infective larvae is 22°C to 30°C (Kates, 1965) with species variation even at constant humidity. Thus within certain limits the rate of development increases with a rise in temperature but the survival rates decrease (Levine, 1963). We can therefore distinguish between minimum temperature at which development is possible, the temperature at which it proceeds at the greatest rate and the temperature optimum for development.

While moisture is essential for the migration of infective larvae from soil and faeces to the herbage (Rogers, 1940; Crofton, 1948), temperature affects their activity and rate of development (Buckley, 1940; Rogers, 1940).

The most favourable conditions for development of the preinfective stages are fairly high temperatures to ensure a rapid rate of development and adequate moisture to ensure that the faeces do not become desiccated before the infective stage has been reached. Studies by various investigators in Nigeria (Lee *et al.*, 1960; Hart, 1964; Enyenihi, 1969; Okon and Enyenihi, 1977; Okon and Akinpelu, 1982) have shown that rainfall, rather than temperature, is the limiting factor for pasture infectivity. This is because temperatures remain favourable throughout the year for the development of infective larvae whereas moisture availability varies with the alternation of the dry and wet seasons. The dry conditions

preclude the development of infective larvae.

Translation

Translation has been defined as the survival, development, dissemination and availability of the free-living stages of helminths and, where appropriate, their intermediate hosts (Michael and Parfitt, 1956). Factors which affect translation are mainly environmental, especially seasonal climatic changes and certain management practices.

Environmental factors affecting translation: The environmental factors which affect the microhabitats and microclimate in which the free-living helminths exist are responsible for the fluctuations in the process of translation. Both temperature and humidity are particularly important, moderate temperatures and high humidity favouring the survival and development of most helminth eggs and larvae (Armour, 1980). The microhumidity depends both on rainfall and the elements influencing the amount of moisture which remains in the soil, i.e. soil structure, vegetation type and drainage. The microhabitats, classified by Crofton (1963) into soil, mat, herbage and host faeces, differ considerably in their physical properties and form a complex ecosystem in which the parasitic larvae have to compete with free-living nematodes, predatory terrestrial fauna such as dung beetles and bacteria, viruses and fungi. According to Armour (1980) the soil type and character influence growth and species composition of herbage. The herbage in turn influences the formation of the layer of mat between the soil and the herbage. The presence of moisture and pockets of air trapped in the mat regulates the rate of temperature change and influences development and survival of helminth larvae. The development and survival of eggs or larvae within faecal matter are again dependent on temperature and moisture. Factors that will affect development and survival within faeces include the host species, moisture content of the faeces, faeces consistency and disintegration, husbandry operations such as harrowing and the activity of certain species of dung beetle (Reinecke, 1960; Bryan, 1972). Temperature and moisture are again the important regulatory factors in the migration of the free-living

stages from the faeces or intermediate hosts onto the herbage. Wet conditions are necessary for larvae to migrate and in the absence of such conditions the faeces act as a reservoir of infection from which larvae are subsequently released when the environment is favourable.

Management practices affecting translation: Certain management practices may affect the availability of helminth infective stages for grazing animals.

Stocking density: An increase in stocking rate coupled with an increase in reproductive performance are principal factors associated with intensive production (Southcott, 1971). Gordon (1948) quoted Ross and Graham (1932, 1933a,b) and Ross *et al.* (1937) to show that a high rate of stocking does not necessarily increase the occurrence of parasitic disease. He noted that the increased chances of infection could be offset by a raised standard of nutrition of the sheep, an observation confirmed by Spedding *et al.* (1967). The insignificant effect of stocking rate on increased chances of infection have also been demonstrated by Cameron and Gibbs (1966), Downey and Conway (1968) and Downey (1969). Zimmermann (1965), however, recorded increased levels of infection with increased stocking rate. Morley and Donald (1980) and Armour (1980) have observed that given equal starting conditions, an increase in stocking rate will:-

- increase the level of contamination of the pasture
- lower the sward height and decrease the quantity of pasture present
- make infective stages (larvae and metacercariae) which are concentrated in the lower quarter of the sward more accessible
- render conditions less favourable for survival and development of free-living forms
- decrease the consumption of pasture per animal
- lower the nutritional status.

Armour (1980) noted that since the microclimate in the short sward is more susceptible to changes in temperature and humidity, the free-living stages become exposed to climatic changes and this may result in high mortality of larvae and reduced translation. However, increased stocking rate is likely to be associated with

increased parasitosis from those species of helminth that are least vulnerable to the effect of decreased plant cover on the microenvironment (Morley and Donald, 1980).

Rotational grazing: Rotational grazing has been widely used as a method to limit parasitic nematode infections and enhance herbage growth. However other studies have shown that in some circumstances it can result in increased numbers of infective larvae on pasture and high worm burdens in grazing animals than occurred under a set-stocking system (Levine and Clark, 1961; Clark, 1966; Michel, 1969, Armour, 1980). Levine *et al.* (1975) showed that lambs under rotation had more nematodes and gained less weight than unrotated control lambs, although rotation increased the amount of pasturage. Under some climatic conditions rotational grazing systems may return animals to a much higher rather than a reduced level of pasture contamination (Brunsdon, 1980). This is because regrowth during the period that the pasture is not grazed provides a more favourable environment for larval translation.

Contamination factors

The level of contamination on a pasture is influenced by several factors including biotic potential of the helminths, stock management, host immune status and hypobiosis (Armour, 1980).

Biotic potential: Heavy contamination of the environment can result from parasites of a high biotic potential (e.g. *Haemonchus contortus*) but control mechanisms within the host/parasite relationship may modify the level of contamination.

Stock management: Stocking density can influence the level of pasture contamination especially in nematode and cestode infections where multiplication of the parasite does not take place outside the final host; it is less important in trematode infections such as flukes where multiplication occurs in the intermediate snail host.

Immune status of host: Sheep and goats become susceptible during late pregnancy and early lactation due to a temporary relaxation of immunity. One of the first observations of this phenomenon was that of Taylor (1935) and was later confirmed by extensive observations by Morgan and Sloan (1947), Morgan *et al.*

(1950), Wilson *et al.* (1953), Crofton (1954) and Connan (1968a,b). Morgan *et al.* (1951) was the first to refer to the stress of pregnancy as a possible factor in the aetiology of the "spring rise" in faecal egg counts. Crofton (1954) demonstrated a definite relationship between this phenomenon and parturition and later in 1958 he suggested the term post-parturient rise as being more appropriate. This post-parturient rise will not occur in ewes that aborted (Dunsmore, 1965) or failed to suckle their lambs (Gibbs, 1967; Connan, 1968b; Jansen, 1968) thus confirming a definite relationship between lactation and post-parturient rise (Brunsdon and Vlassoff, 1971; Salisbury and Arundel, 1970). The host factors responsible for this immunological impairment were studied by Connan (1972) and Kelly and Dineen (1973) who demonstrated an association, either direct or indirect, with circulating levels of the lactogenic hormone, prolactin. In sheep levels of prolactin begin to increase about five weeks prior to parturition and reach a peak in early lactation, to be followed by a steady decline until lambs are weaned. Salisbury and Arundel (1970) observed that the rise in nematode faecal egg counts followed a similar pattern. This phenomenon is now referred to as peri-parturient rise or peri-parturient relaxation in immunity.

Host immunity can also limit the level of contamination by modifying the develpment of new infections or expelling existing ones. Development of gravid worms may be constrained by immuno-arrested larval development, stunting and reduced egg production by adult worms (Urquhart *et al.*, 1962). The expulsion of existing adults may occur due to immunological (Stewart, 1953) or non-immunological (Allonby and Urquhart, 1973) reasons and tends to occur when infective larval stages are readily available and environmental conditions are favourable for translation (Armour, 1980). It is also particularly common in helminths of high biotic potential such as *H. contortus* (Allonby and Urquhart, 1973) and probably reflects a regulatory control by the host and parasite to prevent overpopulation by the latter (Armour, 1980).

Hypobiosis: Arrested development of larvae within the host may occur as a manifestation of acquired immunity (Urquhart *et al.*, 1962) or as a result of prior experience of certain climatic or seasonal influences, a phenomenon referred to as hypobiosis by

Gordon (1970). Trichostrongylid larval inhibition in grazing animals is an adaptation by the parasites which enables them to survive inside the host during periods of prolonged adverse climatic conditions when development and survival of their free-living stages would be hazardous, if not impossible (Taylor and Michel, 1953; Gibbs, 1967; Connan, 1971). The maturation of the hypobiotic larvae generally occurs at a time when environmental conditions are optimal for free-living development and results in increased contamination of the environment.

Nutrition of the host: Chiejina (1986) reviewed the effects of nutrition on helminthiasis. Faults in food intake and quality such as deficiency of protein, vitamins and minerals can lead to a lowering of host resistance to infections which in turn results in enhanced establishment of worm populations in the host or to increased pathogenicity of the existing worm burden and hence to clinical disease (Gibson, 1955; Gordon, 1964; Bawden, 1969; Schillhorn van Veen, 1974; Sykes, 1978). The increased deposition of eggs which results brings about heavy larval contamination on pasture.

Infection of definitive host

The infective larvae are picked from the pasture during normal grazing. The outcome of the infection is determined by the number of parasites present; large numbers may lead to acute and often fatal disease while light infections will produce a chronic or inapparent infection (Schillhorn van Veen, 1978; Opasina and Dipeolu, 1983).

Incidence of Parasitic Gastroenteritis

An outbreak of parasitic gastroenteritis was reported in sheep in England as far back as 1895 by M'Fadyean (1897) who incriminated *Ostertagia circumcincta* as the causal agent. Also observed in sheep suffering from the disease were *Haemonchus contortus*, *Dictyocaulus filaria*, *Protostrongylus rufescens* (*Mullerius capillaris*) and *Trichuris ovis*. Since the reported inflammatory changes sometimes extended into the duodenum, it is possible that the intestinal helminths such as *Trichostrongylus* spp., *Cooperia* spp. and *Nematodirus* spp. may have been present but escaped notice. Various aspects of another widespread outbreak in 1933-34 were described by Taylor (1934a,

1934b, 1934c). The parasites observed in greatest numbers were *Trichostrongylus* spp. (*T. axei*, *T. vitrinus* and *T. colubriformis*) and *Ostertagia circumcincta*.

Widespread outbreaks of trichostrongylosis were reported from Australia in 1932–33 and some aspects of this have been described by Edgar (1933). Of particular importance as causing parasitic diseases of the alimentary canal of sheep in Australia are *H. contortus*, *O. columbianum* and *Trichostrongylus* spp. Some less important ones are *Ostertagia* spp., *Nematodirus* spp. and *Chabertia ovina* (Gordon, 1950).

Isolated outbreaks of parasitic gastroenteritis have been reported and continue to be reported from all over the world. Helminthiasis in Nigerian goats and sheep has been reported by Fabiyi (1968, 1970, 1973), Okon and Enyenihi (1975), Schillhorn van Veen and Brinckman (1975), Akerejola *et al.* (1979) and Fagbemi and Dipeolu (1982). Species of helminths most commonly implicated with parasitic gastroenteritis in this country include *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Oesophagostomum columbianum*, *Trichuris ovis*, *Gaigeria pachyscelis* and *Strongyloides papillosus* (Fabiyi, 1970, 1973; Okon and Enyenihi, 1975). Assuku (1981) recorded a relatively high incidence (80% and 88.3% in sheep and goats respectively) of helminth load in sheep and goats in Ghana particularly during their first year of life. The helminth species involved included *Cooperia curticei*, *Gaigeria pachyscelis*, *Nematodirus filicollis*, *Ostertagia marshalli*, *Ostertagia circumcincta*, *Trichostrongylus axei*, *Oesophagostomum columbianum*, *Trichuris ovis*, *Moniezia expansa*, *Fasciola gigantica* and *Haemonchus contortus*.

The parasites concerned and their pathogenicity

The account below is limited only to those helminth species that have been observed in Cameroon goats and sheep at post-mortem examinations.

Haemonchus contortus: *H. contortus* has a worldwide distribution. The site of infection is the abomasum. In the parasitic phase most of the worms return to the surface of the abomasal mucosa in the fourth stage at which stage the buccal capsule and lancet become functional and late in the stage the larvae are already

sucking blood (Dunn, 1978). The prepatent period in sheep is between 12 and 15 days. The worms have a high biotic potential, the females laying 5,000 to 10,000 eggs per 24 hours (Gordon, 1950).

The principal feature of *Haemonchus* spp. infection is anaemia, due to blood-letting activities of the parasite. There is a reduced erythrocyte level, a decreased haemoglobin level and reduced packed cell volume (Soulsby, 1968; Misra and Ruprah, 1972; Pradhan and Johnstone, 1972; Anosa, 1977; Ogunsusi, 1978; Al-Khshali and Altaif, 1979; Bezubik *et al.*, 1980). In more chronic cases, oedematous swellings (bottle jaw) are frequently seen and others may develop along the ventral aspect of the abdomen. Heavy infections may result in fatal anaemia and may occur even before eggs are produced by the worms since the loss of blood commences with the fourth stage larvae. Other clinical manifestations of *H. contortus* infestation include paleness of the mucus membrane, loss of body weight and wool, harsh wool and constipation followed by diarrhoea (Misra and Ruprah, 1972).

Trichostrongylus: *Trichostrongylus* has a worldwide distribution. In the warmer countries it is one of the important causes of parasitic gastroenteritis (Dunn, 1978). Infection is by ingestion of the third larval stage and development proceeds in the alimentary canal. The prepatent period in ruminants is between two and three weeks. The pathogenic effects have been described by Soulsby (1968) and include desquamation of the intestinal mucosa as a result of penetration of the mucosa by intestinal forms and anaemia in heavy infections. The worms may be associated with chronic wasting disease or with acute and often fatal infections. In acute cases, there is neither emaciation nor anaemia but weakness in the legs leading to death. In chronic cases, there may be alternating constipation and diarrhoea coupled with emaciation, dryness of the skin and mild anaemia.

Trichostrongylosis is characteristically a disease of young sheep, mature animals developing resistance due to a combination of age and experience of a previous infestation (Gordon, 1950).

Oesophagostomum: *O. columbianum* has a worldwide distribution but is common in tropical and subtropical regions. The development of the parasitic stage within the host has been

described by Dunn (1978). The L_3 passes into the mucosa of any part of the intestine (from the pylorus to the rectum) and become enclosed in nodules in which the first parasitic moult takes place. The moult occurs before the tenth day, the L_4 emerge and pass to the lumen of the large intestine where they grow into adults. The nodules normally disappear after the L_4 have left them, but in animals which have had experience of infection, the larvae may remain in them for more than a year. The prepatent period is between 40 and 50 days, varying with the species.

Gordon (1950) reported that extensive nodular formation of both large and small intestines interferes with absorption, bowel movement and digestion. There may be peritonitis and multiple adhesions when the nodules rupture to the peritoneal surface. Nodules which rupture into the lumen of the bowel produce ulcerous lesions. Adult worms cause marked thickening of the bowel wall, congestion and large production of mucous. The infection interferes with appetite, growth and wool growth. Sood (1960) observed that adults penetrate rather deeply into the mucosa and cause erosion and desquamation of the surface epithelium with development of necrotic areas in the mucosa.

Clinical signs include marked and persistent diarrhoea in lambs. In chronic cases there is an initial diarrhoea followed by constipation with occasional spells of diarrhoea. There is progressive emaciation and general weakness, dryness of skin and unthrifty wool (Soulsby, 1968). Other clinical observations include anorexia, loss in body weight, decrease in packed cell volume, haemoglobin, erythrocytes, total plasma protein, plasma albumin and albumin/globulin ratio (Horak and Clark, 1966).

Bunostomum: *Bunostomum trigonocephalum* occurs in the small intestine of sheep and goats throughout the world, both in tropical and temperate areas and the limiting factors in the distribution are probably the high moisture and temperature requirements of its preparasitic phase (Dunn, 1978). Infection may be by mouth or by skin (Ortlepp, 1939; Dunn, 1978). The prepatent period is between 4–8 weeks depending upon the experience of the host. The adult worms attach themselves to the intestine and suck blood (Soulsby, 1968).

Clinical signs include progressive anaemia with associated changes in the blood picture (Lucker and Neumayer, 1946; Soulsby, 1968; Graham and Charleston, 1971), hydroemia and oedema; diarrhoea is not infrequent (Soulsby, 1968).

Cooperia *Cooperia* has a worldwide distribution. The commonest forms that have been recorded from sheep are *C. curticei* and *C. oncophora*. *C. curticei* is generally the most widely distributed species of the genus and usually the most common (Crofton, 1963). Infection of the host is by mouth. The worms penetrate into the mucosa of the small intestine and suck blood (Soulsby, 1968). Clinical signs and lesions are similar to those of trichostrongylosis.

Strongyloides papillosus This parasite has a worldwide distribution. The infective larvae of the parasite generation is able to penetrate through the skin of the host and via the blood to the lungs, up the trachea to the pharynx and on to the intestine (Soulsby, 1968; Dunn, 1978). The prepatent period is nine days or less in the species occurring in domesticated animals.

It is commonly regarded as of very slight pathogenic significance but heavy infections (of up to 100,000 or more larvae) may be associated with death in 13–41 days (Soulsby, 1968). Pathological signs include erosions of intestinal mucosa. Soulsby (1968) observed that field outbreaks were associated with catarrhal enteritis of the upper small intestine but fatal cases were few. The pathogenic potential of this worm has been shown by Turner (1955, 1959), Turner and Wilson (1958), Turner *et al.* (1960) and Round (1963) in sheep.

Trichuris ovis This parasite has a worldwide distribution. Infection occurs when the egg containing the first stage larva is swallowed. Thapar and Singh (1954) reported that the prepatent period was 7–12 weeks in sheep. The adult worms are found in the large intestine, mainly in the caecum.

Clinical trichuriasis is hardly ever seen in sheep and goats (Dunn, 1978) and Soulsby (1968) remarked that naturally acquired infections are seldom severe enough to cause clinical disease.

Moniezia **spp.**: Even though this species may not be of much significance, there is little doubt that heavy infestations in young

animals exposed to malnutrition are of some consequence (Gordon, 1950). With increasing age the animal becomes more resistant (Euzeby, 1967). Euzeby (1967) carried out extensive investigations on these anoplocephalid tapeworms and reported on their infestation in ruminants. The intermediate hosts are mites of the family Oribatidae. The ruminant becomes infested on pasture by the ingestion of vegetation to which oribatid mites are attached. A sheep infested with *M. expansa* begins to shed gravid segments after about six weeks.

In the majority of cases, taeniasis runs a chronic course, the commonest clinical signs being a slowly progressive anaemia, with emaciation and a reduction in red cell count and in the haemoglobin content. These clinical signs are much less severe than in the case of trichostrongylosis. There is a variable degree of enteritis in chronic infestations. In the acute form the enteritis is exudative and occasionally also haemorrhagic.

***Paramphistomum* spp.**: Water snails serve as the intermediate hosts. The adult form occurs in the rumen and reticulum of sheep, goats and cattle in various parts of the world. The most common species in sheep, goats and cattle in Africa is *P. microbothrium*. The immature stages of *Paramphistomum* spp. are capable of causing enteritis (Srivastava, 1938; Mudaliar, 1945; Gordon, 1950). Nothing is known of the ill effects produced by the adults.

Epidemiological considerations

Gibson (1973) observed that lambs may acquire infection from two sources: first, residual larval infection on the herbage as a result of previous grazing and secondly larvae derived from worm eggs passed in the dung of the ewe. The post-parturient rise in faecal egg count observed in the ewe is an important feature of this second source of infection. Heath and Michel (1969) produced evidence to show that in ewes and lambs running on pasture that had initially very low levels of larval infection, the rise in faecal egg output of the ewe was responsible for a rise in pasture larval count followed later by a sudden rise in the faecal egg count in lambs. The residual larvae played a negligible role in initiating infection in lambs. Boag and Thomas (1971) confirmed this observation and concluded that the worm eggs passed by the ewes in the course of

the post-parturient rise were the source of nearly all the worms that were the cause of disease in their lambs. Boag and Thomas (1971) and Gibson and Everett (1973) observed further that the great output of worm eggs in the faeces of the lambs in turn gave rise to a second and rather low peak of herbage infestation.

The residual larval infection becomes significant when lambs are grazed on pasture that had been previously contaminated such as overwintering pasture infestation. In this circumstance the lambs will become a source of worm eggs much sooner and will make a significant contribution to the disease producing infestation. Thomas and Boag (1972) analysed the relative roles played by residual larval infection and the post-parturient rise and observed that while ewes run on contaminated pasture showed one peak of larval infection, the lambs showed two peaks of faecal egg count, a first one attributed to worm infection derived from the residual herbage larval infection and a second one much later arising from larvae produced from eggs passed by the ewes in post-parturient rise. Further evidence of the role of residual larval infection in the initiation of infection in lambs is given by Gibson and Everett (1971, 1972).

Climatic changes play a highly significant role in determining the seasonal pattern of worm burdens. The seasonal availability and abundance of the free-living stages of worms is a key factor in the occurrence and severity of parasitic infection. Climatic factors determine whether and how rapidly free-living development can take place, what proportion of individuals succeed in becoming infective and for how long. The studies on the seasonal pattern of nematode infections carried out in Nigeria may very closely depict the situation likely to prevail in Cameroon. Fabiyi (1968) and Kuil (1970) concluded from studies carried out on goats and sheep respectively in the Zaria area of Northern Nigeria that the survival of trichostrongyle larvae was nil during the dry season and no infection could take place from pastures during this period. Ogunsusi (1979) made a similar study in the same area using tracer lambs and reported that large numbers of infective trichostrongyle larvae were ingested with the pasture from the onset of the wet season in June till October. Infectivity started to decline from November until the end of January after which the pasture became completely free of parasitic nematode larvae and

remained so until the end of May. The increase in number of adult trichostrongyles in ruminants at the end of the dry season has also been demonstrated by Hart (1964), Kuil (1970) and Fabiyi (1970). Fabiyi in a further study in 1973 showed an increase in infection in the wet season in almost all the species. High counts of *Haemonchus* and *Strongyloides* started early in the rains while high counts of *Gaigeria*, *Oesophagostomum* and *Trichostrongylus* did not occur until late in the wet season. He attributed the differences in the order of succession and in the peak incidence largely to differences in the fecundity constant and generation interval of the species. This is based on the suggestion by Crofton (1963) that nematode parasites which have either a low fecundity constant such as *T. colubriformis* or a long generation interval such as *Oesophagostomum* and *Gaigeria* or both attributes would tend to appear later in the favourable season than those with a short generation interval such as *S. papillosus*.

The circumstances during the dry season are unfavourable for the survival of the free-living stages of trichostrongyles in the field (Sprent, 1946; Hart, 1964; Ogunsusi, 1978). Trichostrongyles have been shown to counter the adverse conditions of the dry season through arrested development inside the host (hypobiotic fourth stage) (Schillhorn van Veen and Ogunsusi, 1978; Vercruysse, 1985). The development of these larvae is normally resumed just before the beginning of the following wet season and is probably initiated by seasonal influence (Gibbs, 1973). The subsequent rise in faecal trichostrongyle eggs has been demonstrated by Fabiyi (1973) and Gildorp and Schillhorn van Veen (1976). Chiejina and Fakae (1984) observed at Nsukka in the derived savanna zone, which has a dry season of about five months duration, that preparasitic development is possible throughout the year, although it occurs more readily in the rainy season. However, pasture infectivity, is negligible or nil during the dry season since environmental conditions are unsuitable for larval migration although, in contrast to the drier northern savanna zones, L_3 are protected inside faecal deposits during the dry months.

Acute haemonchosis is commonly observed in young lambs at the beginning of the rainy season. The rapid rise in worm burden a

few weeks after the onset of the rains rapidly leads to contamination of the pastures and sheep, especially lambs, are exposed to a heavy build-up, resulting in acute helminthiasis in untreated flocks (Fabiyi, 1973; Schillhorn van Veen and Brinckman, 1975).

Pomroy *et al.* (1986) in a comparative study of faecal strongylate egg counts of goats and sheep on the same pasture found that eggs per gram of faeces for sheep were consistently lower than for goats. Adult sheep were able to resist larval challenge effectively, although adult goats appeared to develop some measure of resistance compared to the younger goats.

Haemoglobin types in sheep and goats

Genetically determined variation plays an important role in the susceptibility of sheep (and goats) to gastrointestinal helminths (Clunies-Ross, 1932; Stewart *et al.*, 1937; Warwick *et al.*, 1949; Scrivner, 1964; Preston and Allonby, 1979a). Studies using *Haemonchus contortus* have shown that particular breeds and individual animals within a breed are more resistant to infection (Whitlock, 1958; Loggins *et al.*, 1965; Preston and Allonby, 1979a, 1979b). Genetic resistance may thus play a significant role in the control of helminths, especially *H. contortus*, in traditionally managed flocks where anthelmintics are rarely used and self cure is often the only way in which worm burdens of sheep and goats are eliminated (Preston and Allonby, 1979a).

Genetic resistance can be exploited either by breeding from stock which is apparently resistant to infection or by using genetic markers for host resistance (Preston and Allonby, 1979a). One genotype which has been linked with resistance to haemonchosis is haemoglobin. Results from field studies and experimental infections (measuring faecal egg counts, adult worm burdens and haematological parameters) have provided evidence that sheep with HbAA were more resistant to *H. contortus* and exhibited self cure more often than animals with HbAB or HbBB types (Evans *et al.*, 1963; Jilek and Bradley, 1969; Allonby and Urquhart, 1976; Preston and Allonby, 1979a). Post mortem findings by Preston and Allonby (1979a) demonstrated that this phenomenon was due to differences in the establishment of adult *H. contortus* and not to the suppression of egg laying capacity or an alteration of male to female adult worm

ratio.

Haemoglobin types in sheep and goats have been identified using various techniques including electrophoretic (paper electrophoresis, starch gel electrophoresis and cellulose acetate electrophoresis) and chromatographic techniques, iso-electric focusing and amino acid analysis. Earlier investigations by Harris and Warren (1955) on sheep and goats revealed two adult haemoglobin types of distinctly different mobilities, both migrating towards the anode, and one foetal haemoglobin which in goats moved faster than either of the adult haemoglobins but in sheep had a mobility intermediate between the fast and the slow adult haemoglobins. The existence of two genetic variants of haemoglobin in sheep of different breeds has also been demonstrated by Cabannes and Serain (1955), Evans *et al.* (1956, 1957), Van der Helm *et al.* (1957) and Huisman *et al.* (1958a). The haemoglobin moving more rapidly towards the anode at pH 8.6 was called HbA and the slower migrating component HbB. The electrophoretic patterns of the two adult haemoglobin types identified in Dutch sheep by Van der Helm *et al.* (1957) and designated Hb1 (slow moving in paper electrophoresis) and Hb11 (fast moving haemoglobin) are closely similar to Hbs B and A respectively identified in English sheep.

As the occurrence of the haemoglobin appears to be genetically determined, it is possible to get figures on their inheritance if the Hb types of the parents are known. The work of Evans *et al.* (1956) and Huisman *et al.* (1958a) indicated that haemoglobin is inherited in a simple Mendelian manner. Thus the haemoglobin types are determined by two allelic genes each responsible for the formation of one kind of haemoglobin. These authors also showed that HbII (or HbA) had a higher oxygen affinity of blood than HbI (or HbB) and attributed this to the intrinsic differences of the haemoglobin molecule. HbA (haemoglobin type HbII) has an adaptive significance and may have originated by mutation in sheep living at high altitudes. Since HbA has a higher oxygen affinity, anoxia (less oxygen availability to the tissues) is avoided by these animals having a significantly higher total haemoglobin content of the blood compared with the values found in sheep with the HbB. The values found in sheep heterozygous for

both haemoglobins are intermediate.

Sheep may thus be classified into three types: A, B and AB according to whether they possess one, or another, or a mixture of two distinct haemoglobins (Harris and Warren, 1955; Cabannes and Serain, 1955; Evans *et al.*, 1956, 1957; Van der Helm *et al.*, 1957). The results of a survey carried out by Evans *et al.* (1957) on more than 30 different British breeds indicated that large differences in gene frequencies (or the relative frequencies of the three types of animal) occur from breed to breed with mountain and hill breeds tending to have rather high frequencies of HbA while lowland breeds tended to have high frequencies of HbB. These findings were confirmed by the work of Templeton *et al.* (1972) and suggested that haemoglobin type may be of some adaptive significance, with HbA having an adaptive advantage over HbB in elevated regions. Van der Helm *et al.* (1957) obtained a higher incidence of the HbI (HbB) than HbII (HbA) in the Dutch sheep, both in homozygous and heterozygous animals, suggesting that the former is the normal type.

It has been shown (Huisman *et al.*, 1958a, 1958b) that quantitative changes in the amounts of Hbs A and B may occur in sheep heterozygous for both variants (AB sheep) when such an animal is submitted to the stress of severe anaemia. Blunt and Evans (1963) discovered a new type of haemoglobin in sheep with HbA which were made anaemic by bleeding. Subsequently, van Vliet and Huisman (1964) and Blunt (1965) confirmed this finding and showed that it was produced in sheep which had HbA or AB but not in the B sheep. Van Vliet and Huisman (1964) called the new haemoglobin type HbC. Thus in the AB sheep, the designated HbC was present in much larger quantities during the experimental anaemia and ultimately replaced HbA entirely.

Braend *et al.* (1964) similarly reported HbN in a highly anaemic lamb. This haemoglobin is probably the same as HbC reported by van Vliet and Huisman (1964). It has a slower rate of migration than HbB in alkaline starch gels and has been found only in animals of haemoglobin phenotypes AA and AB. Further evidence of HbC being produced after severe haemolysis in animals having previous phenotypes AA or AB Hb types has been given by Tucker (1966) and Kitchen *et al.* (1968). However, investigations by Efremov and Braend

(1966) demonstrated the occurrence of HbC in normal sheep (being present at birth and persisting throughout in all lambs of phenotypes AA and AB but absent in BB sheep) as well as being provoked experimentally by bleeding.

Where the formation of HbC is provoked by bleeding, it gradually disappears and the original haemoglobin (A or AB) returns to its former proportion (van Vliet and Huisman, 1964). Kitchen *et al.* (1968) found that HbC remained in decreasing quantities for approximately four months, an indication that it is probably a normal haemoglobin rather than a precursor form of HbA and is a stable haemoglobin associated with red blood cells having a normal life span.

Schillhorn van Veen and Fularanmi (1978) investigated the haemoglobin types of northern Nigerian sheep and identified two haemoglobin variants: Hb type A and Hb type B. The majority of the animals carried HbB type, results which confirm earlier findings by Evans *et al.* (1958) for the Nigerian Fulani sheep. On the other hand, Olusanya (1975) found that HbA was more common in the Dwarf sheep in Ibadan. On the basis of these observations it may be deduced that under arid conditions the adaptation to a dry environment appears to be a stronger selection pressure than the resistance to haemonchosis. The selective advantage of HbB sheep under arid conditions is unknown but HbB sheep are known to show better reproductive performance (Evans and Turner, 1965), and lower lamb mortality (Olst and Evans, 1970) and are probably more economic users of sodium and water (Michell, 1975).

Unlike sheep where only two normal haemoglobin types (HbA and HbB) have been reported, four haemoglobins (Hbs A, B, D and E) have been described in normal goats using electrophoretic and chromatographic techniques as well as amino acid analysis (Huisman *et al.*, 1967, 1968; Adams *et al.*, 1968, 1969; Wrightstone *et al.*, 1970). Khanolker *et al.* (1963) described the existence of three phenotypes namely Hb AA, Hb AB and Hb BB in Indian goats and attributed these to two alleles at the locus controlling haemoglobin synthesis. Other investigators including Joshi *et al.* (1975), Goel and Nair (1976), Singh *et al.* (1977), Baruah and Bhat (1980), Fesus *et al.* (1983) and Bhat (1986) reported the existence of the two haemoglobin variants with

HbB being rare.

Tucker *et al.* (1983) found that each major A and B zone in goats consisted of two bands, a stronger forward and a weaker backward band. The electrophoretic pattern described for HbC in anaemic goats differs from that observed in sheep. According to Tucker *et al.* (1983) HbC presumably forms as a distinct band ahead of the more anodal A zone. In the AB lysate the cathodal major HbB bands virtually disappeared on anaemia as did the more cathodal of the HbA bands, while a prominent anodal HbC band appeared. These authors further observed that anaemic HbA, HbAB and HbB goats all produce a HbC with an identical electrophoretic pattern. This contrasts with the situation in sheep where animals with haemoglobin phenotype B have been shown not to produce HbC at all. HbC in goats is normally present in small amounts in all non anaemic individuals and it is the only haemoglobin synthesized in goats of all phenotypes under conditions of severe anaemia (Tucker *et al.*, 1983).

In addition to the two most frequent haemoglobin types (HbA and HbB), two rarer haemoglobin types (HbD and HbE) have been described in Spanish goat breeds (Huisman, 1970; Barbancho *et al.*, 1984).

Researchers in Nigeria have used non-conventional letter symbols to describe the haemoglobin variants in Nigerian goats (an indication of the confusion that appears eminent in the proper identification and naming of the haemoglobin types in goats). The earliest reported work is that of Enyenihi (1974). He identified three haemoglobin variants in Kano Brown and Red Sokoto goats which he designated normal or HbN (with an identical electrophoretic mobility to the human HbA), slow or HbS (with an electrophoretic mobility to the human HbS) and fast or HbF (faster in its migration towards the anode than any of the human haemoglobins). In the Sahel goats, besides the three haemoglobins demonstrated in the Kano Brown and Red Sokoto goats, a fourth type or HBS' (extra slow) was observed and existed only as a heterozygote in association with the normal haemoglobin; no homozygote phenotype of the extra slow haemoglobin was encountered.

The normal (HbN) haemoglobin had the highest frequency in all

three breeds followed by the slow (HbS), the fast (HbF) and finally the extra slow (HbS') alleles. In terms of the frequencies of the different phenotypes, the HbNS genotype was the commonest, followed by the homozygote normal (HbNN), heterozygote HbNF, heterozygote HbFS, homozygote SS in that order. Buvanendran *et al.* (1981) carried out further investigations on the haemoglobin variants in the Red Sokoto goats and applied the same letter symbols used by Enyenihi (1974) to represent the haemoglobin phenotypes they identified.

Their studies largely confirmed the observations of Enyenihi (1974) concerning the haemoglobin variants and pattern of distribution of the phenotypes in the Red Sokoto goats. They additionally demonstrated the presence of animals of the HbSS which were missing from the population studied by Enyenihi (1974). The main limitation of the studies on haemoglobin types in Nigerian goats was the failure of the investigators concerned to relate their findings to similar investigations in other countries especially with regard to the use of conventional letter symbols to identify the haemoglobin types.

Experimental studies with *Haemonchus contortus*

The pathogenic effects of the various worms involved in parasitic gastroenteritis and the pathological changes associated with the infestation in sheep and goats have been studied through artificial infections. The pathogenic and pathological effects of *Haemonchus contortus* infections have been extensively investigated.

Pradhan and Johnstone (1972) showed that prolonged exposure of weaned lambs to 500 third stage infective *H. contortus* larvae per day or 3,500 larvae per week proved to be highly pathogenic to the animals. The pathogenicity was higher when the lambs were infected with a small number of daily (daily group) doses than when the same number of larvae were given as one dose at weekly intervals (weekly group). A manifestation of resistance in the form of inhibition of growth in the fourth larval stage occurred in some sheep after prolonged exposure. Dineen *et al.* (1965) found that with daily doses of 100 larvae, larvae given after day 10 failed to develop beyond the fourth stage.

They further observed that delayed development was greater with

continuous daily doses of 100 larvae than after one dose of 3,000 larvae. The packed cell volume in sheep used by Dineen *et al.* (1965) fell to approximately 22 by day 63 (after 30 daily doses) without mortality. On the other hand, Pradhan and Johnstone (1972) observed mortality after 49 x 500 daily doses of larvae with a final mortality of 100% by day 84. In the group receiving 7 x 3,500 L3 weekly doses, mortality occurred between days 50 and 104. Thus the build-up of resistance was accelerated when animals received smaller daily doses of infection than when they received larger daily doses.

Al-Khshali and Altaif (1979) demonstrated a fall in packed cell volume, haemoglobin concentration and total red cell count in Awassi and Merino sheep following a primary infection with *H. contortus* (500 L3/kg body weight).

Scott *et al.* (1971) considered haemoglobin concentration to be the best indicator of the degree of haemonchosis. A spectacular depression of the haemoglobin concentration accompanied by weakness and death are the classical features of haemonchosis (Roberts and Swan, 1982). Pradhan and Johnstone (1972) observed an increase in mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) without an appreciable change in the mean corpuscular haemoglobin concentration (MCHC) following *Haemonchus* infection. Silverman *et al.* (1970) noted that lambs on a basic protein diet survived exposure to as many as 10,000 *H. contortus* but death occurred when higher doses (25,000 L3, 50,000 L3) were given, apparently as a result of failure of the haematopoietic system.

Haemonchus infections have also been shown to affect the protein levels in serum. Kerboeuf (1977) recorded decreases in serum total protein, albumin and total globulin levels following infection of sheep with *H. contortus*. Al-Khshali and Altaif (1979) while also noting a progressive reduction in total serum protein and serum albumin concentration observed no significant changes in serum globulins during the course of the infection. Kuttler and Marble (1960) found a reduction in total serum protein and albumin fraction and increases in the alpha-1, alpha-2, beta and gamma globulins in lambs clinically parasitized with *H. contortus*. Uppal and Rai (1978), on the other hand, while confirming a decrease in the percentage of serum albumin, noted an increase in the alpha globulin and a decrease in the beta globulin. Shastry and Ahluwalia (1972)

concluded from their studies on experimental infections of goats with *H. contortus* that there was a significant drop in total protein, albumin and globulin/albumin ratio while globulin percentage increased.

Plasma pepsinogen concentration has been found to be directly related to abomasal damage and is a much earlier indication of worm build-up than faecal egg count, enabling control measures to be taken in good time (Thomas and Waller, 1975). Suten and Kedar (1983) noted that in sheep and lambs with moderate natural gastrointestinal nematode infection intensities (more than 1100 epg) the pepsinogen levels were 1.211±0.165 and 0.546±0.146 mIU/ml plasma respectively, comparatively higher than the values in animals with negative faecal tests, 0.475±0.096 and 0.429±0.176 respectively. Kerboeuf (1980) recorded increased concentrations of pepsinogen in serum from sheep with experimental *H. contortus* infections, the increase occurring earlier than in *Ostertagia circumcincta* infections. Experiments with naturally infected sheep have shown a direct relationship between the number of worms in the abomasum and level of pepsinogen (Kerboeuf and Leimbacher, 1977; Kerboeuf, 1980). The correlation between pepsinogen concentration and the number of worms present in the abomasum is valid only for mean flock values, there being no such correlation in individual animals.

Silverman and Patterson (1960) examined the histological changes in *H. contortus* infection at various times in susceptible and resistant sheep. Detailed comments on the progressive development of histopathological changes up to 25 days after infection were presented by Charleston (1965). This latter worker examined abomasal and related lymph node changes in lambs, following single or daily challenges, concentrating on specific cellular mobilization and changes in mucosal depth. Hunter and Mackenzie (1982) studied the pathogenesis of *H. contortus* up to 35 days post challenge. They examined the development of the parasite in relation to specific cellular mobilization, haematology, parasitology, gross pathology and histopathology at 4, 7, 12, 18, 22 and 35 days after infection.

They observed that the host erythropoetic system attempts at various times in the course of the disease to compensate for the blood loss from the blood sucking activity of the worms. The corrective host response attempts have also been discussed by Dargie and Allonby (1975).

Diagnosis of Parasitic Gastroenteritis

Faecal egg count as an ante-mortem means of diagnosing naturally acquired gastrointestinal nematode infection of domestic livestock has been practised for many years (Edwards and Wilson, 1958; Tripathi, 1966; McKenna, 1981). Strong support for monitoring these counts as a rational method of determining the optimum timing of control measures against sheep nematodes was given by Heath (1961). However, many workers including Sprent (1946), Gordon (1950, 1958b, 1967), Roberts (1957), Stewart and Gordon (1958), Rossiter (1964), Hart (1964), Barrow (1964), Kingsbury (1965), Gibson (1965), Rubin (1967), Michel (1968) and Fabiyi (1973) have demonstrated pitfalls inherent in the use of such counts for assessing the severity of strongyle worm infections in ruminants.

Roberts and Swan (1981) confirmed that inaccuracies may arise if egg counts are used to predict individual animal's parasite burdens. However the techniques provide information with a satisfactory degree of precision in the diagnosis and control of haemonchosis in flocks. An examination of the third stage infective larvae obtained from cultures by the method described by Whitlock (1956) affords a ready means of differential diagnosis of helminth infections (Gordon, 1967).

According to Brunsdon (1970) a satisfactory estimate of the level and/or composition of flock infection can be made on the basis of egg counts from at least 10-12 faecal samples and/or worm counts on at least two, or preferably more, gut samples. Fabiyi (1973) in his study of seasonal fluctuations in goats in the savanna belt of Nigeria, preferred to record fluctuation in nematode burdens by worm counts because these take into account immature non-ovigerous worms which may be as important as the mature ones and there are a number of varying factors, such as the host immune status, which may suppress egg production in ovigerous worms, while variations in the host's faecal output, the consistency of the host's faeces and the host food intake all contribute to an unreliable prediction of the degree of worm burden (Gordon, 1950, 1967) - as estimated from egg counts.

The value of estimating herbage larval numbers in epidemiological studies has been described by Thomas (1959), Michel (1966), Gibson and Everett (1968) and Lancaster (1970). A pasture sample provides an estimate of the average concentration of infective larvae on the herbage of a defined area of pasture at that

time (Waller *et al* ., 1981). A number of methods for recovering and counting infective larvae from pasture samples have been described (Taylor, 1939; Crofton, 1954; Parfitt, 1955; Durie, 1959; Donald, 1967; Lancaster, 1970). Gettinby *et al* . (1985) compared the recovery of larvae from herbage collected manually with herbage collected from sheep with oesophageal fistulae on five days during the grazing season. They concluded that both methods sampled consistently and neither of them appeared to provide a bias in favour of a particular genus. Pasture larval counts may complement the use of tracer animals in defining the sequence of events leading to clinical helminthiasis.

Waller *et al* . (1981) described a worm count from a tracer animal as providing an integrated expression of the larval intake of that animal less the integrated losses over the period for which it has grazed a pasture. The use of tracers can also yield information on the subsequent fate of ingested larvae, e.g. arrested development. In a comparative study of direct pasture sampling and tracer animals as estimators of larval abundance these authors concluded that worm counts from tracer sheep, especially those grazing for four weeks rather than for shorter periods, may systematically underestimate the infective larval populations on pasture at high levels of abundance owing to density dependent worm loss.

A measure of plasma pepsinogen has been shown to be of value in indicating the severity of the abomasal lesion (Anderson *et al* ., 1965; Thomas and Waller, 1975; Kerboeuf, 1980) and is therefore of practical value in the diagnosis of the disease.

Control of Parasitic Gastroenteritis

Extensive reviews on the epidemiology and control of nematode infections of grazing animals have been carried out by Michel (1969, 1976a), Gordon (1973), Brunsdon (1980) and Chiejina (1986). Since it is not practically possible to eradicate most helminth species, and as such a course is not generally required in order to control economically important helminth diseases of livestock, control should aim at ensuring that parasite populations do not exceed levels compatible with economic production (Brunsdon, 1980). Over the years various management strategies have been advocated for the control of parasitic gastroenteritis.

These have included rotational grazing, pasture resting, alternate grazing by hosts of the same species, alternate grazing by hosts of

different species, mutliple dosing with anthelmintics, integrated control and the use of forecasting systems.

Rotational grazing: Rotational grazing has been recommended for years as a method of controling nematode infections of domesticated animals. However, Levine (1959) remarked that a pasture rotation system had not yet been discovered that was better than no rotation at all in preventing parasitism in lambs. Michel (1969) also noted that any practical system of rotational grazing can have no relevance to the control of trichostrongylid worms. Rotational grazing was advocated in the belief that all eggs in faeces develop quickly to the infective stage and thereupon die off quickly and also that it results in more efficient pasture use and higher levels of productivity. Apart from some circumstances in which the botanical composition of the pasture is modified, with possible effects on productivity (McKinney,. 1974) there is no compelling evidence to support either belief (Morley, 1978). Various rotational systems have been studied by different investigators (Whitten and Macfarlane, 1953; Levine and Clark, 1961; Gibson and Everett, 1968; Michael, 1969; Levine *et al*., 1975). These workers have all arrived at the conclusion that the value of parasite control by rotational grazing was not sufficiently well founded for the practice to be advocated. Comparisons between set-stocking and rotational grazing of both hoggets and calves in which paddocks have been spelled from these animals for periods of up to three weeks have produced only small differences in parasite burdens (Clarke and Filmer, 1958; McMeekan, 1954).

There appears to be a potential for set-stocking as a comparatively more economical and effective method of reducing infection from pasture than rotational grazing.

In fact scarcely a single trial in which the effect on worm burdens of set-stocking and of rotational grazing have been compared has shown any significant or consistent difference between the two systems (Michel, 1964).

Alternate grazing by hosts of the same species: Spedding (1956a, 1956b) advocated a modified form of controlled grazing in which lambs and ewes graze a pasture divided into plots so that the lambs can use plots which are withheld from the ewes until later. In theory the more resistant ewes reduce the pasture contamination so that the lambs always have clean pasture on which to graze. This system depends on a form of rotational grazing and has the same

basic difficulties as any other and so may be considered impracticable except under special circumstances. In the absence of other alternatives, lambs would probably be better weaned onto pastures grazed previously by wethers rather than by ewes with lambs (Morley and Donald, 1980).

Alternate grazing by hosts of different species: The cattle/sheep alternative is the most common. The effectiveness of alternate grazing with different species of host depends on the degree of cross-transmission of parasites. Morley and Donald (1980) distinguished three levels of cross-transmission:

(a) very low cross infectivity without reproduction

(b) reduced cross infectivity and/or shortened period of patency sufficient to endanger the survival of the parent species if the heterologous host subsequently grazes alone.

(c) Only minor differences in infectivity which could possibly disappear within a few generations of selection.

The first level includes species of *Ostertagia, Oesophagostomum, Nematodirus* and *Bunostomum* . There is practically no cross-transmission between sheep and cattle of parasites of these genera (Roberts, 1942; Porter, 1953; Rose, 1968). The second level includes species of *Cooperia* and intestinal *Trichostrongylus* since some of these can certainly reproduce in the alternate host (Roberts, 1942; Porter, 1953; Rose, 1968), although their long term persistence is in doubt. The third level comprises *Trichostrongylus axei* and *Haemonchus contortus placei* . Cross-transmission of *T. axei* seems sufficiently effective that mixed grazing of alternation of sheep and cattle at intervals of several months has nothing to offer in the control of this parasite (Kates and Turner, 1960).

In *Haemonchus* endemic regions, it is unlikely that alternate grazing of young sheep and young cattle could be relied upon to aid control of this parasite in either host (Morley and Donald, 1980). This is because even if calves exerted some adverse effect on *H. contortus* population increase, as has been shown by Ross and Purcell (1969), sheep seem sufficiently susceptible to *H. placei* to both contaminate pastures and to suffer from the effect of the infection. However, alternate grazing of sheep with yearlings or older cattle might be effective, because cattle over 18 months old have usually developed a strong resistance to *H. placei* (Roberts *et al* ., 1952) and are likely

to become resistant to *H. contortus* even more quickly. In two trials in Australia, Southcott and Barger (1975) and Barger and Southcott (1975) concluded that there was little evidence of transmission of cattle parasites to sheep whereas transmission of sheep parasites to cattle was a more common occurrence involving *H. contortus* and *T. colubriformis* (Brunsdon, 1980).

Multiple dosing with anthelmintics: Morley and Donald (1980) defined multiple dosing as three or more anthelmintic treatments at regular intervals of six weeks or less and without reference to the contamination status of the pastures. What makes this system attractive is the fact that it demands no changes in the farmer's traditional management. Drenching at constant, e.g. monthly, intervals over long periods owes more to convenience and simplicity than to anything else, since pasture infectivity and host responses are not notable for constancy. If epidemiological factors such as seasonal changes in rates of infection and changes in host resistance are considered, then the intervals between multiple doses as well as starting and finishing times might be just as important as the total number of doses. Chiejina (1986) observed that frequent deworming of traditionally managed herds may not always be justified since low levels of infections are likely to be present in many cases.

Morley and Donald (1980) observed that apart from economic considerations, the main threat to multiple dosing is an increase in the incidence of drug resistant parasites, even though two or more drugs with different metabolic pathways are used alternately. Several species of ovine nematodes have developed resistance to anthelmintics after repeated exposure (Kelly *et al*., 1976). Kelly and Hall (1979) suggested that the development of resistance can be delayed by the use of management strategies that, when combined with highly efficient anthelmintics, will limit their use to a minimum and reduce the selection pressures towards drug resistance. Edwards *et al* . (1986) has recommended a parasite control programme which incorporates selection of the anthelmintics to be used following a test for anthelmintic resistance. Rapid and inexpensive methods of determining resistant levels based on the ovicidal action of benzimidazole anthelmintics as described by Egerton (1969) have been given by Le Jambre (1976), Coles and Simpkin (1977), Le Jambre *et al* . (1976) and Hall *et al* . (1978). An egg hatch assay for resistance to levamisole in trichostrongyloid

nematode parasites has recently been described by Dobson *et al*. (1986). Where resistance is diagnosed, the use of that group of anthelmintics in regular drenching programmes should be discontinued and drugs in an alternate group should be used (Prichard *et al*., 1980).

Morley and Donald (1980) concluded that if parasites are to be controlled and anthelmintics preserved, treatment must not be casual or opportunist, but based on sound epidemiological principles and aided by effective grazing management so that each treatment is effective as well as necessary for maximum economic productivity. This is the basis of what Brunsdon (1980) referred to as "integrated control".

Integrated control: Brunsdon (1980) suggests three interrelated approaches to integrated helminth control: by grazing management, by use of anthelmintics and by the utilization of natural or artificially induced immunity. The most efficient control requires the complete integration of all three facets which is possible only on the basis of a full understanding of the epidemiology of infections, that is an application of the knowledge of life cycles, larval ecology and epidemiology to husbandry practices designed to prevent or limit contact between parasite and host. Therefore control measures must be specifically designed to suit the local environment and climatic conditions as well as meet the special type of husbandry involved.

The essential requirement of integrated control is the provision of "safe" pastures for susceptible animals at appropriate times.

Brunsdon (1980) explains that a safe pasture may not be parasite-free but has too few infective larvae to be directly damaging to susceptible animals. Safe pastures may be produced by eliminating grazing from certain areas of the farm for specified periods. Fodder crops, new pastures, hay and silage aftermath all initially provide safe pasture. Rotational grazing is a specialized form of pasture spelling but it would require an interval of three months or more under some climatic conditions to produce a safe pasture by spelling (Brunsdon, 1980). Other specialized methods of producing safe pastures include grazing helminthologically resistant stock along with susceptible animals. There is some evidence (Herlich, 1965; Smith and Archibald, 1969) that such mixed grazing may confer an immunological benefit in that species of nematodes

adapted to one host may stimulate immunity when ingested by another host and yet not exert a detectable pathogenic effect. Contamination may also be reduced by sequentially stocking a pasture with different species (alternate grazing) or by strategic sequential grazing of resistant animals of the same species.

An alternative to changing to safe pasture (per se) is the use of critical strategic anthelmintic treatments to suppress contamination at times when free-living development is minimal. This ensures that immediate reinfection is low (Southcott *et al* ., 1976) and such treatment can be used to enhance or reinforce natural discontinuities in pasture infestation resulting from climatic factors. Anderson (1972, 1973) noted that two such treatments used in conjunction with the seasonal decontamination of the pasture resulting from the dry summer in Victoria, Australia, produced safe grazing for autumn and winter. Since the weather conditions vary from year to year, the timing of such treatments must, however, be related to actual weather patterns, the first administered when pasture is noticeably drying off and the second in the middle of the dry period. Chiejina (1986) suggests for the Northern savanna areas of Nigeria that the readily available clean pastures at the end of the long dry season could be exploited in an integrated control programme by treating all animals in the flock or herd with an effective anthelmintic during the dry season when pasture infectivity is negligible and subsequently moving them to clean pastures at the start of the rains. Fabiyi (1973) proposed for the Northern savanna area of Nigeria three strategic drenchings. The first treatment in the last week of November is aimed at reducing dry season burdens to the barest minimum when grass is scanty and malnutrition is likely to occur and the effect of even light infestation may be severe. The second treatment should be given in May when favourable pasture conditions for helminth infective stages are available. This should eliminate low levels of all worms and moderately high levels of such forms as *Oesophagostomum* and should delay any outbreak of helminthiasis in the host from such forms as *Haemonchus* and *Strongyloides* . A third anthelmintic treatment in early August would forestall any clinical outbreaks of helminthiasis (from forms with long generation intervals or low fecundity constants such as *Trichostrongylus* , *Gaigeria* and *Oesophagostomum*) until after the rains when the November treatment is given to eliminate whatever burden has been built up during the latter months of the rains.

Where intensive goat husbandry without rotational grazing is practised he recommended four treatments in May, July, September and November to replace the May, August and November drenchings.

In conclusion, integrated control is facilitated by an understanding of the sequence and pattern of infection in order to determine the strategic control periods. The recommended control system comprises a drenching during those periods, each treatment being accompanied by a grazing change to a safe pasture.

The Role of Forecasting in Preventive Control

Attempts have been made to relate seasonal outbreaks of helminth disease to climatic changes on the basis that certain minimum of mean temperature and of rainfall are required. Knowledge of the importance of larval bionomics led to the development of biohythergraphs to predict times at which helminth burdens are likely to reach problem levels (Gordon, 1948). They were constructed by plotting and joining monthly mean rainfall and mean maximum temperatures. On these biohythergraphs Gordon (1948) superimposed lines indicating the limits of the climatic conditions which he especially found to be most favourable for the free-living stages of different parasitic nematodes and for their development. He then compared the resultant annotated biohythergraphs with the known incidence of parasites in different localities. Biohythergraphs have been used since then to interpret ruminant nematode epidemiology in Australia by Gordon (1948, 1950, 1953, 1958b), Roberts *et al* . (1952), Pullar (1953) and Forsyth (1953); in Canada by Cameron (1956); in Ethiopia and in the U.S.A. by Levine (1959).

Even though biohythergraphs have been valuable in assessing the prevalence of parasitic nematodes in different localities at different seasons, there have been several limitations. Levine (1963) noted that biohythergraphs cannot be used to predict the situation for any specific year as they are based on average conditions over a longer period of time. Thus the biohythergraphs for the same area in different years may be very different and they have been less successfully related to the incidence of disease in a particular year. The approach is not adequate if precision is required. Furthermore, they are based only on two climatic parameters - temperature and precipitation, thereby ignoring other climatic factors that might be of great importance in influencing larval development and survival on pasture. These remarks were confirmed by Gordon (1963).

The most noticeable success in the use of meteorological data to predict the incidence of a parasite disease is that of the fascioliasis forecasting method devised by Ollerenshaw and Rowlands (1959). A forecasting system for fascioliasis in Northern Ireland based on the number and distribution of wet days (i.e. days with 1mm of rain) was proposed by Ross (1970) and later in 1975, he applied the same system for Scotland but with a slight adjustment of the incidence criteria - predictions were made in relation to a standard year. Ollerenshaw and Smith (1966, 1969) predicted the incidence of nematodiriasis in the British Isles on the basis of the mean of one foot earth temperature for March. Thomas (1974) and Vlassoff (1975) have each separately demonstrated a system for predicting times of peak larval availability on pasture.

In recent years efforts have been directed towards the development of mathematical simulation models to improve the precision of forecasting. Barger *et al* . (1972) and Gettinby *et al* . (1974) have successfully developed respectively models for simulating populations of *H. contortus* on pasture and the pattern of the liver fluke *Fasciola hepatica* from temperature data. More recently Thomas *et al* . (1986) developed a simulation model for *Ostertagia circumcincta* infective larvae on pasture grazed throughout the year by ewes and lambs and used it to test the effect of anthelmintic treatment at different times in the grazing season.

Michel (1971, 1976a,b) argued that while forecasting may be of considerable assistance in deciding on the use and/or timing of a specific treatment, its use in determining modification of management is incompatible with efficient husbandry. Provision would need to be made every year for changes of pasture in anticipation of the eventuality that a warning could be issued. He preferred incorporation of changes of pasture as a feature of the management system every year even if some years it may be unnecessary. This proposal would thus seem to make forecasting unnecessary. However, since one might expect yearly changes in the pattern of infection, forecasting would determine the critical period for change of pasture thus ensuring that production losses as a result of too early or too late changes of pasture is avoided.

Application of Helminth Control Strategies On-farm

There have been two main views; one view advocates an on-the-spot assessment of the epidemiological factors relevant to that farm on the part of the adviser. An alternative view advocates

the use of one of a number of ready-made grazing systems. Bawden (1976) believed that an awareness of the general principles of control should enable a broad strategy to be worked out with little individual practices, based on experience or observations, superimposed. Brunsdon (1980) proposed three steps for the preventive control of helminths in extension programmes.

(1) Explanation of basic principles and rationale.

(2) Proposal of a model scheme together with an outline of the various ways and means of achieving the objectives.

(3) The suggestion of permissible compromise procedures to overcome foreseeable management difficulties.

JUSTIFICATION

The above review has summarised the current situation of small ruminant production in the developing countries (an approach which largely depicts the Cameroon situation), the impact of helminth infections on production and health, and the measures that have been proposed for control of the disease.

In Cameroon, mortality records at Government and private intensively managed farms have often indicated heavy worm burdens in dead sheep and goats, a possible indication of the involvement of parasitic gastroenteritis. Regular treatments at short intervals (e.g. monthly) have failed to produce the desired prophylactic control since such treatments are not based on any epidemiological studies. In the traditional village flocks, occasional high mortalities are reported. As the husbandry practices of the farmers have not been studied, the extension services are incapable of adequately advising the farmers in such situations. Since helminth control measures have to be developed that meet the local requirements (e.g. husbandry practices, climate, etc.), it becomes imperative that such studies be undertaken in Cameroon.

There is a clear indication that practically no research has been carried out on parasitic gastroenteritis of small ruminants in Cameroon, a disease that is probably responsible for most of the production losses especially on intensively managed farms. In an effort to make an important contribution in this field, and especially in order to boost small ruminant production in Cameroon, an investigation on parasitic gastroenteritis in relation to small ruminant production was conceived with the following objectives in view:-

(1) To identify, describe and evaluate the main production

systems of sheep and goats.

(2) To identify the chief constraints in production in order to allow for formulation of proposals for improvement.

(3) To determine the overall epidemiological pattern of parasitic gastroenteritis in sheep and goats through monitoring of clinical, helminthological, climatological and production parameters.

(4) To give a better understanding of the influence of weather, management practices, nutrition, age, sex and breed of the host on the incidence of, and susceptibility to, helminth diseases in sheep and goats.

(5) To determine whether there are separate goat/sheep strains of *Haemonchus* and how the animals of each type differ in their response to these.

(6) To design and test various management systems and anthelmintic regimes appropriate for optimum productivity in sheep and goats.

EXPERIMENTAL

STUDIES

PART II

SURVEY ON SHEEP AND GOAT PRODUCTION

INTRODUCTION

Cameroon is located in the central African zone between latitudes 2° and 14° north and longitudes 8° and 16° east (Fig. 1). The survey on sheep and goat production was carried out in the North West Province of Cameroon (Figure 1). The vegetation of this province is a combination of forest and savanna (mountain, woodland and Sudano-Guinean) with tall trees and pastures (Figure 2). The landscape consists of rolling hills and valleys. The hills go to about 1500 metres in height while the valley bottoms are about 1000 metres deep. The dry season extends from mid-November to mid-March. During this period the vegetation on the hills, which is mainly grass pastures, dries up while the mixed vegetation of grass and trees in the valleys and around the banks of streams remains green throughout the year. The approximate annual temperature range is 11-32°C while the annual rainfall amounts to about 2000 mm.

Politically the North West Province is divided into five divisions, namely Momo, Mezam, Bui, Donga-Mantung and Menchum (Figure 1). The background studies on traditional management of sheep and goats were carried out in Momo and Mezam while the survey on haemoglobin types was carried out on sheep and goats collected from all the five divisions of the North West Province.

The survey studies were intended to:-

(a) Identify and describe the main production systems of sheep and goats in the North West Province of Cameroon.

(b) Assess the performance under each system so identified.

(c) Evaluate the managemental factors which are critical to disease incidence.

(d) Evaluate the disease components influencing productivity levels.

(e) Identify the chief constraints in production to allow formulation of proposals for improvements in the existing management systems geared to increase production.

(f) Determine the haemoglobin variants in indigenous breeds of sheep and goats as background studies to the experimental work

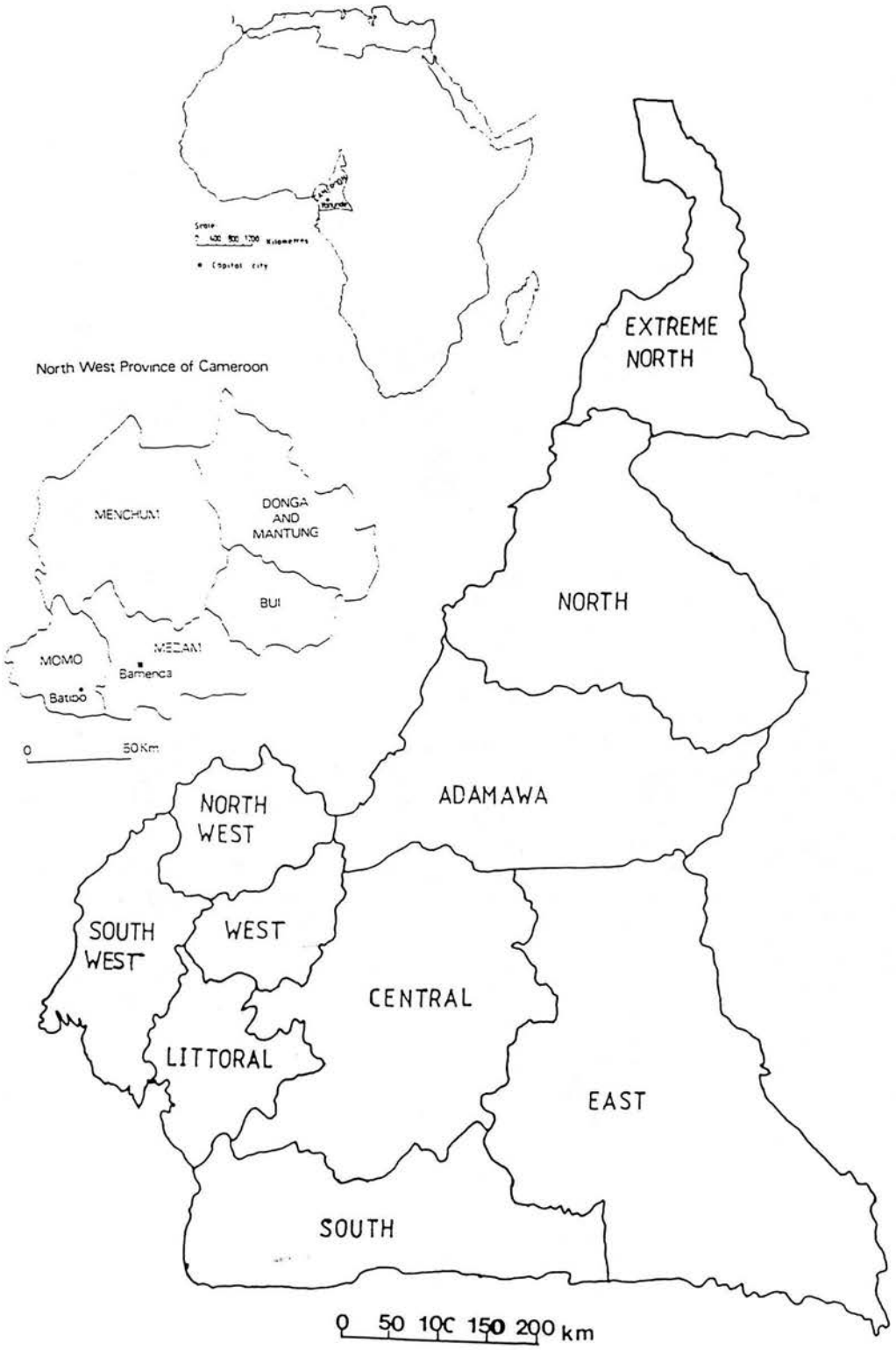


Figure 1 Administrative map of the Republic of Cameroon and the North West Province

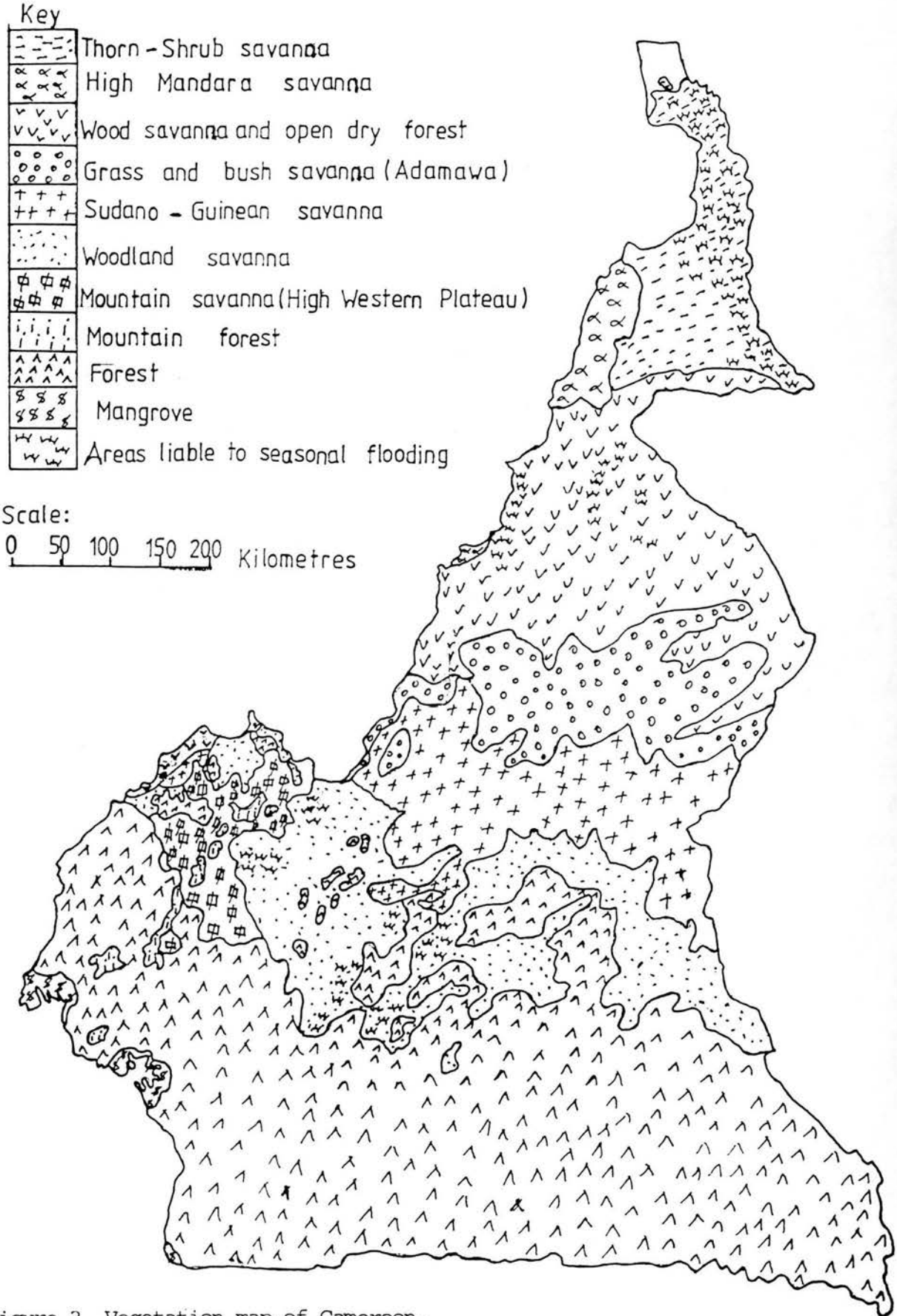


Figure 2 Vegetation map of Cameroon.

on haemonchosis.

SURVEY ON TRADITIONAL MANAGEMENT OF SHEEP AND GOATS

EXPERIMENTAL DESIGN

Background studies on traditional management of sheep and goats were conducted by the use of two questionnaires. The smaller questionnaire (Appendix 1) was used to interview livestock farmers who did not keep sheep or goats, to find out why this was so. There was no preselection of the farmers interviewed in this category but instead those persons who were approached as part of the main survey but said they did not keep small ruminants were interviewed using the smaller questionnaire. Thirty-four such farmers from Momo and Mezam divisions (17 from each division) were interviewed.

The main questionnaire (Appendix 2) was used with 50 sheep/goat farmers in Momo and 65 in Mezam divisions to give an indication of the role of sheep and goat production under traditional management in the North West Province of Cameroon. Since sheep and goats are reared by most householders in these divisions, ten villages from each division were selected on the basis of their accessibility and distribution within the division. In each village the homes were visited and the first five small ruminant farmers encountered in their homes were interviewed. All the farmers approached readily agreed to be interviewed except in two instances where the persons concerned had urgent commitments. To minimize error from interrogations by different interrogators, the interviews were all conducted by the author, who also filled in the questionnaires. Where a need for interpretation arose, as when interviewing a farmer who did not understand English, it was ascertained that the interpreter clearly understood the question before attempting to communicate it to the farmer.

The main respondents in all cases were the animal owners, a sheep/goat owner being defined as a person who owned, controlled and made decisions concerning the animals. Where a small ruminant farmer had helpers, their assistance was sought in answering appropriate questions. Supplementary questions, not included in the questionnaire, were asked when necessary to obtain more details as appeared relevant at the time. This supplementary information is detailed where it was subsequently used in the

consideration of the results.

The questionnaire was designed to permit the collection of data on flock structure, grazing management, housing facilities, feed supplementation, watering patterns, kidding/lambing frequency, and other production factors including offtake rate and marketing facilities. Data was also obtained on mortality, morbidity and case fatality rates, the ability of the owners to recognise signs of disease, the importance they attached to various disease entities, health control measures employed by the farmers and their understanding of the epidemiology of the diseases.

RESULTS

Small ruminants are kept in Momo and Mezam divisions of the North West Province of Cameroon mainly by small-scale subsistence farmers in the rural areas. Eighty-four percent of these holders are also crop farmers while 48% are engaged in some off-farm work such as carpentry, bricklaying, tailoring, petty trading etc. Of the 65 small ruminant farmers interviewed in Mezam division, 59 (91%) keep goats as against only 16 (25%) who keep sheep. Similarly in Momo division, of the 50 farmers interviewed, 47 (94%) keep goats as against only 8 (16%) who keep sheep. Taking the two divisions together, 92% of the small ruminant farmers keep goats as against only 21% who keep sheep. Thus there is a greater emphasis on goat production than on sheep production. This is reflected in the number of farmers who prefer goats to sheep or who for other reasons are forced to keep only goats.

The main reason advanced by the majority of small ruminant farmers for preferring goats to sheep is a traditional belief that a man needs to have had both male and female children before rearing sheep. The assumption is that sheep adversely affect a woman's fertility through their high prolificacy, which indirectly deprives the woman of children, thus making her unable to bear her own children. Sheep, they claim, should only be kept by elderly people or people who no longer need children. Other reasons for preferring goats to sheep include the fact that sheep are less resistant to disease than goats; they are more easily killed by a passing vehicle because of their sluggish attitude; they are easily strangulated when tethered, and they are more difficult to tether than goats. Furthermore, they are indiscriminate grazers, eating everything that comes their way and so can be very destructive to crops. They are also regarded as filthy animals, preferring to lie on top of their faeces and urine than on litter, and their frequently soft faeces makes cleaning of the shed difficult.

The farmers who keep only sheep do so for two main reasons. There are possible religious inclinations, such owners being mainly Moslems and secondly because they regard sheep as being easier to manage than goats because of their more gentle nature.

Whatever their preference for sheep or goats, small ruminant farmers keep small ruminants for the following reasons:-

(1) As a source of revenue for family needs and social obligations, such as school fees and books, settlement of hospital bills, bride price, etc. Small ruminants can generate quick money to solve urgent problems.

(2) They serve as a source of meat for marriage, birth and death celebrations and other ceremonial occasions. They also supply meat in convenient quantities for the family and extensive storage facilities are not needed.

(3) As a form of investment with low capital input.

(4) Because they are easy to manage since they fend for themselves through their grazing and browsing habits and therefore the labour requirement is low. It is thus easier to employ cheap family labour.

(5) Small ruminant rearing enables one to profitably utilise household wastes and harvest crop residues.

(6) They provide manure for use on vegetable and crop farms.

(7) They are kept for aesthetic interest and as a hobby.

People who do not keep small ruminants do so for various reasons:-

(1) Lack of initial capital.

(2) Preoccupation in fulltime crop farming or off-farm work.

(3) Because they rear other forms of livestock. These people may have no particular bias against small ruminants.

(4) Because they have previously owned small ruminants but lost them through theft, predation or disease and have been discouraged from restocking.

Flock structure

The indigenous sheep and goats found in the North West Province of Cameroon are of the Grassland Dwarf type (Plates 1 and 2). They are normally kept by individual owners. However, there was one instance encountered of a joint investment by two brothers. The ownership pattern of small ruminants in the two divisions studied is shown in Table 1. Each farmer has only one flock irrespective of whether it is mixed or of a single species. Flocks with only goats are much the most common. There are probably more people with

Plate 1a Grassland Dwarf sheep - Ram

Plate 1b Grassland Dwarf sheep - Ewe

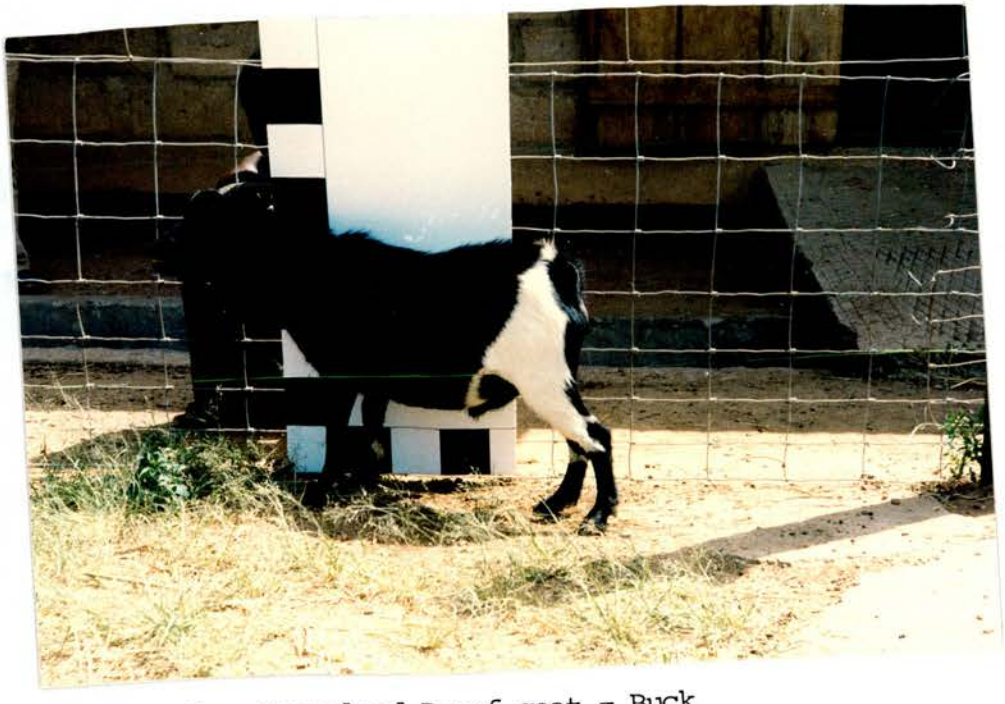


Plate 2a Grassland Dwarf goat - Buck

Plate 2b Grassland Dwarf goat - Doe

Plate 3a Red Sokoto goat (Rousse) - Buck

Plate 3b Red Sokoto goat (Rousse) - Doe

mixed flocks than with only sheep (P = 0.5) and it would appear more people in Mezam (24%) than in Momo division (16%) keep sheep (P = 0.4). These differences were, however, not conventionally significant (P > 0.05).

Table 1 Ownership patterns of small ruminants in Momo and Mezam

Flock composition	Number and proportion of farmers involved		
	Momo	Mezam	Combined
Goats only	42 (84%)	49 (75%)	91 (79%)
Sheep only	3 (6%)	6 (9%)	9 (8%)
Mixed flocks	5 (10%)	10 (15%)	15 (13%)

The flock sizes (Table 2) are generally small but with some tendency towards larger sizes in mixed flocks than in flocks with only one species. In mixed flocks, more sheep than goats are kept on average but the difference is insignificant.

Table 2 Flock size of sheep and goats in Momo and Mezam divisions

Flock composition	Mean flock sizes and standard deviation (and range)		
	Momo	Mezam	Combined
Goats only	6±7 (1-50)	7±7 (1-33)	7±7 (1-50)
Sheep only	13±6 (7-18)	3±2 (1-5)	6±6 (1-18)
Mixed flocks:			
Goats	5±4 (1-12)	6±6 (1-19)	5±5 (1-19)
Sheep	6±9 (2-23)	7±9 (1-29)	7±9 (1-29)
Total	11±10 (3-27)	13±14 (2-48)	12±12 (2-48)
*All goats	6±7 (1-50)	7±7 (1-33)	6±7 (1-50)
*All sheep	9±8 (2-22)	6±7 (1-29)	7±8 (1-29)

*Counting only goats or only sheep respectively in mixed flocks

The detailed flock structure is given in Table 3. Overall there are slightly more female sheep than goats even among the breeding flock. However, while the male:female ratio for animals of breeding age is similar (1:11) for the sheep and goats in Mezam it is markedly different for the two species (1:4 for sheep and 1:13 for goats) in Momo division. However, the difference was not statistically significant ($P = 0.8$).

Of the young stock, again more females than males are kept (Table 3). Castrates make up only a very small percentage of the total flock. Castration is a more common practice in goats than in sheep with only 20% of the sheep rearers as against 48% of the goat farmers ($P < 0.005$) interviewed in this survey practising castration and only on a very limited scale. They castrate the animals for two main reasons: to facilitate management, as otherwise the males often stray off after females and do not readily return, and to improve weight gains. The age at which castration is carried out varies greatly between individual farmers ranging in goats from as early as three days to as late as two years. The age range is narrower in sheep, varying between three and six months.

Table 3 Flock structure (as percentage of total) of sheep and goats in Momo and Mezam divisions of the North West Province

		Flock structure Momo	Mezam	Combined
Sheep:				
Males:	Rams	*9 (13%)	6 (6%)	15 (9%)
	Male lambs	1 (1%)	2 (2%)	3 (2%)
	Castrates	2 (3%)	-	2 (1%)
Total Males		12 (17%)	8 (9%)	20 (12%)
Females:	Ewes	34 (49%)	68 (72%)	102 (62%)
	Female lambs	24 (34%)	18 (19%)	42 (26%)
Total Females		58 (83%)	86 (91%)	144 (88%)
Grand total		70	94	164
Sex ratio (ram:ewe)		1:4	1:11	1:7
Number of flocks		8	16	24
Goats:				
Males:	Bucks	13 (5%)	22 (5%)	35 (5%)
	Male kids	28 (11%)	34 (8%)	62 (9%)
	Castrates	2 (1%)	10 (2%)	12 (2%)
Total Males		43 (16%)	66 (16%)	109 (16%)
Females:	Does	164 (63%)	233 (56%)	397 (58%)
	Female kids	54 (21%)	119 (28%)	173 (25%)
Total Females		218 (84%)	352 (84%)	570 (84%)
Grand total		261	418	679
Sex Ratio (bucks:does)		1:13	1:11	1:11
Number of flocks		47	59	106

*Figures not enclosed in brackets represent actual number of animals

Management systems

The farming system in the North West Province is agro-pastoral but with a stronger emphasis on agriculture. This is reflected in the small flock sizes and the very limited grazing land available especially during the cropping season (March-August). Six all-year-round management systems have been identified for sheep and goats in the

two divisions studied (Tables 4 and 5).

Table 4 Management systems of sheep and goats in the North West Province

Management system	Parameter	Number of animals or flocks with percentage in brackets Sheep			Goats		
		Momo	Mezam	Combined	Momo	Mezam	Combined
Tethering/ tethering	No. of animals	32	38	70	117	136	253
	No. of flocks	3(38%)	4(25%)	7(29%)	27(57%)	21(36%)	48(46%)
	Mean flock size	11	10	10	4	6	5
	Range of flock size	3-22	1-29	1-29	2-7	1-19	1-19
Tethering/ semi-extensive	No. of animals	5	17	22	70	173	243
	No. of flocks	2(25%)	5(31%)	7(29%)	14(30%)	20(34%)	34(32%)
	Mean flock size	3	3	3	5	9	7
	Range of flock size	2-3	1-6	1-6	2-12	2-24	2-24
Tethering/ extensive	No. of animals	2	18	20	25	70	95
	No. of flocks	1(13%)	5(31%)	6(25%)	5(11%)	15(26%)	20(19%)
	Mean flock size	2	4	3	5	5	5
	Range of flock size	-	1-6	1-6	1-9	1-14	1-14
Semi-intensive/ semi-intensive	No. of animals	13	17	30	50	6	56
	No. of flocks	1(13%)	1(6%)	2(8%)	1(2%)	1(2%)	2(2%)
	Mean flock size	13	17	15	50	6	28
	Range of flock size	-	-	13-17	-	-	6-50
Semi-intensive/ semi-extensive	No. of animals	-	-	-	-	33	33
	No. of flocks	-	-	-	-	1(2%)	1(1%)
	Mean flock size	-	-	-	-	33	33
	Range of flock size	-	-	-	-	-	-
Extensive/ extensive	No. of animals	18	4	22	-	-	-
	No. of flocks	1(13%)	1(6%)	2(8%)	-	-	-
	Mean flock size	18	4	11	-	-	-
	Range of flock size	-	-	4-18	-	-	-

The subtitles indicate the management method in the cropping season (March-August) and the non-cropping and dry seasons (September-February) successively.

(a) **Tethering/tethering:** The animals are kept in a shed during the night whereas they are tethered during the day throughout the year within the vicinity of the house or along the roadside. The location where the animal is tethered is often changed each day. Only adults and lambs/kids that have reached a destructive age (that is from about six months) are tethered. The younger lambs/kids are left loose and roam in the vicinity of their dams. Male and female animals and the different age groups are not separated when inside the shed.

(b) **Tethering/semi-extensive:** In this system the animals are kept in the shed at night but in the daytime they are tethered during the cropping season and

left on free range during the non-cropping and dry seasons. When they are on free range they usually return to the shed on their own or they may be brought back by somebody. The owner normally counts the animals each time to ensure that all returned.

Table 5 Management systems of mixed flocks of sheep and goats in the North West Province

Management system	Parameter	No. of animals or flocks with percentages in brackets								
		Momo			Mezam			Combined		
		Sheep	Goats	Total	Sheep	Goats	Total	Sheep	Goats	Total
Tethering/ tethering	No. of animals	25	10	35	38	31	69	63	41	104
	No. of flocks		2(40%)			4(40%)			6(40%)	
	Mean flock size	13	5	18	10	8	17	11	7	17
	Range of flock size	3-22	-	8-27	1-29	1-19	2-48	1-29	5-19	2-48
Tethering/ semi-extensive	No. of animals	5	14	19	12	13	25	17	27	44
	No. of flocks		2(40%)			3(30%)				5(33%)
	Mean flock size	3	7	10	4	4	8	3	5	9
	Range of flock size	2-3	2-12	4-15	3-6	2-9	5-12	2-6	2-12	4-15
Tethering/ extensive	No. of animals	2	1	3	7	5	12	9	6	15
	No. of flocks		1(20%)			2(20%)			3(20%)	
	Mean flock size	2	1	3	4	3	6	3	2	5
	Range of flock size	-	-	-	1-6	1-4	5-7	1-6	1-4	3-7
Semi-intensive/ semi-intensive	No. of animals	-	-	-	17	6	23	17	6	23
	No. of flocks	-	-	-			1(10%)		1(7%)	
	Mean flock size	-	-	-	17	6	23	17	6	23
	Range of flock size	-	-	-	-	-	-	-	-	-

(c) **Tethering/extensive:** Here the animals are kept in a shed without wall enclosures at night and tethered in the daytime during the cropping season whereas during the non-cropping season they are free roaming both day and night. While they are free roaming the owner is not concerned about where they spend the night. However, the majority of such animals stay under the veranda at night or when it is raining.

(d) **Semi-intensive/semi-intensive:** The animals are confined in a shed during the night and left during the day throughout the year in fenced paddocks of at least two hectares in size. The fences are constructed of sticks and raffia bamboos.

(e) **Semi-intensive/semi-extensive:** The animals in this system are on semi-intensive management during the cropping season, grazing fenced paddocks during the day. During the non-cropping season, they are free roaming. In both situations they usually return to a shed at night.

(f) **Extensive/extensive:** In this system animals are free roaming 24

hours a day throughout the year. They browse and scavenge freely on whatever feeds are available near the households and in the neighbourhood. No shed is provided although the animals may stay under the veranda during rain and at night.

In the systems of management that involve tethering, some farmers leave the animals on a short tether inside the shed to prevent fighting and escaping while others untie the tether to permit mating. Of the six systems of small ruminant management two are most popular: tethering/tethering and tethering/semi-extensive (Table 4). About 78% of the goat farmers and 58% of the sheep farmers encountered in this survey managed their animals by these two systems. Some 73% of mixed flock owners also utilized the two systems (Table 5). At the other extreme are three systems: semi-intensive/semi-intensive, semi-intensive/semi-extensive and extensive/extensive which together were used by only 17% of sheep owners and 3% of goat owners.

However, semi-intensive/semi-intensive and semi-intensive/ semi-extensive management systems were more likely to be used with larger flocks of up to 50 or more animals. Less sizeable flocks are found under management systems that utilize tethering at some stage during the year (Table 6).

Table 6 Comparative flock size in management systems that involve or do not involve tethering

Management system	Overall flock size (mean and range)	
	Sheep	Goats
Involves tethering	6 (1-29)	6 (1-24)
No tethering	13 (4-18)	30 (6-50)

Daily grazing schedule

During the rainy season most farmers (65%) send their animals out for grazing before 8.00 a.m. because those who take them out are mainly children who must do so before starting off for school. A smaller proportion of farmers (19%) wait till about 9.00 a.m. for the dew to evaporate from the pasture before letting out the animals. This category of farmers believe that

dew can bring about illness in the animals especially if they eat snails and millipedes which would poison them. A few other farmers (12%) wait much longer both for the same reason and in addition to allow the animals to get really hungry so that they will eat well.

Early grazing of animals is also favoured during the dry season both for the same reasons as in the rainy season and also because the farmers believe that the dew on the pasture makes it more palatable since most of the grass at this time is very dry.

A small proportion of farmers (4%) have no consistent grazing schedule as it depends on their off-farm activities.

The majority of farmers (96% during the rainy season and 53% during the dry season) bring their animals back to the shed between 4.00 p.m. and 8.00 p.m. each day. They are brought in much earlier during the rainy season to escape the dew settling on the pastures.

Housing

Four housing types have been identified for small ruminants in Momo and Mezam divisions of the North West Province:-

(1) Open shed in a night paddock (2%).

(2) One room of the living house (16%).

(3) Enclosed shed attached to the living house or separate from it (50%).

(4) The veranda of the living house with no enclosing walls (30%).

The type of house used by most farmers (50%) is an enclosed shed with walls made of varying combinations of sticks, tree fern and bamboos. Most of these sheds are roofed with zinc but a few others have thatched or grass roofs (Plate 4). Gaps of varying dimensions are left in the walls for aeration and light. If the shed is attached to a living house it shares one wall with it, or it may stand on its own.

The flooring system is equally varied and can be one of four types:-

(1) Cement (3%)

(2) Mud (27%)

(3) Raised slats (22%) (Plate 5)

(4) Planks or logs laid on the earth or slightly raised on blocks, stones or other logs (48%) (Plate 4).

No preferences of flooring system with flock size or type was observed. Faeces were often allowed to block the gaps between the planks, logs or slats and accumulate on the slats and under the building and only rarely removed.

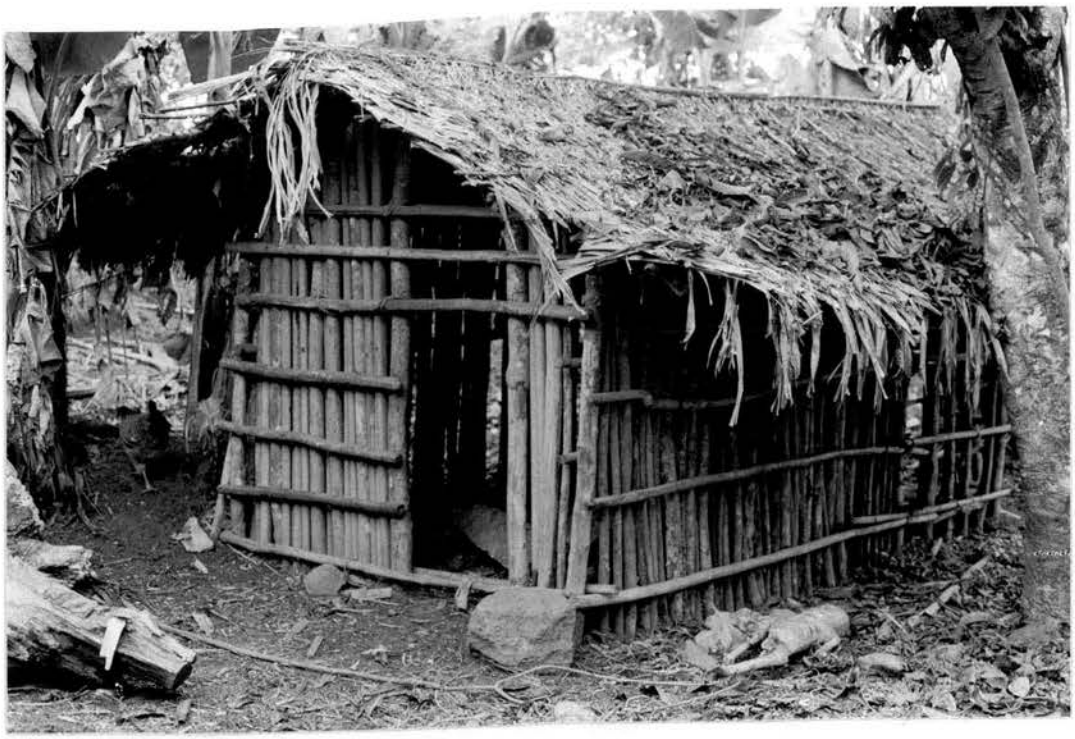


Plate 4 Thatch roofed shed for small ruminants with floor of logs raised on other logs.

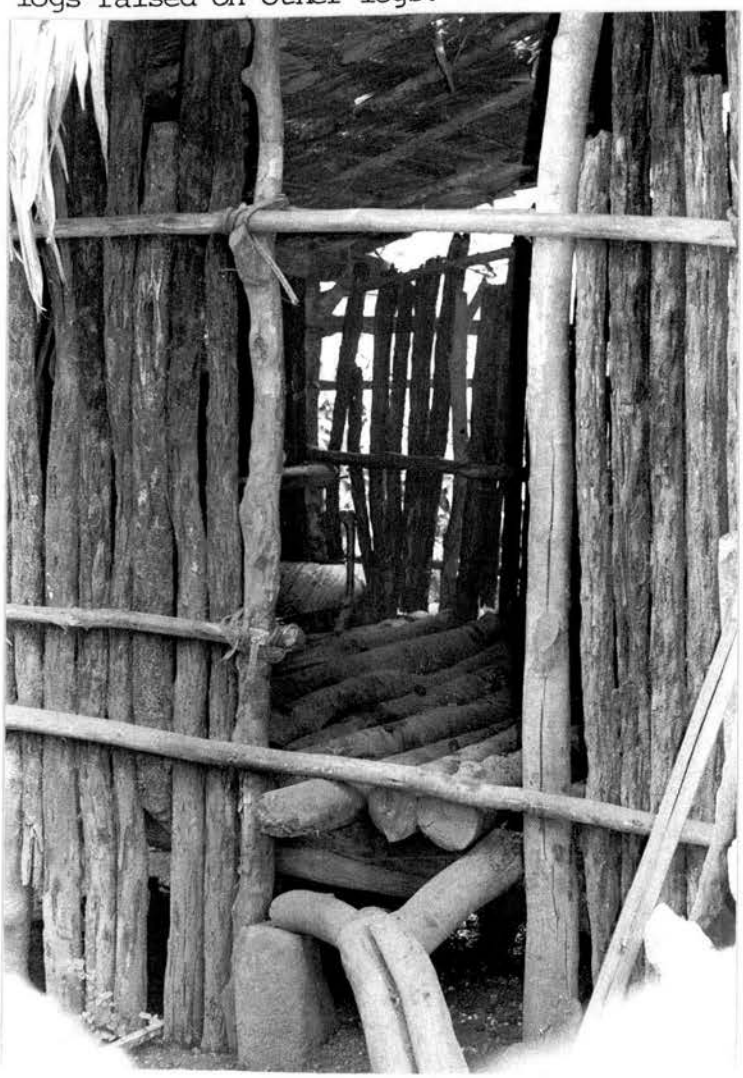


Plate 5 Shed for small ruminants with raised slatted floor.

Cement or mud floors were cleaned more often, at least once every week.

Nutrition and watering

Village sheep and goats depend mostly on the natural vegetation and scraps of household wastes for their nutrition. When free roaming, they may also feed on harvest wastes in the fields. Intentional feed supplementation is rarely adopted but most farmers give their animals salt regularly as a means of getting them used to the owner and as prophylaxis against various diseases. Watering was not considered essential by about 47% of the farmers interviewed. Some did not think that sheep/goats drink water at all while others thought that the animals were able to obtain enough water for their daily requirements from the pastures on which they graze. About 43% of the farmers give their animals water on a more or less regular basis while the other 10% provide water only occasionally.

Reproduction

Some 93% and 83% of the farmers interviewed in Momo and Mezam respectively disclosed that most of their goats kid only once a year. In contrast 50% and 62% of the farmers in Momo and Mezam respectively observed that lambing occurred once or twice a year at an equal frequency in their sheep flocks. Mating is normally uncontrolled, occurring whenever a female comes into oestrus and the rams/bucks are often the young males in the flock under one year of age that have not yet been sold. Moreover, the progeny of the most active breeding ram/buck is often the main source of ram/buck replacement so that inbreeding is common. Infrequent parturitions were more common with goats than with sheep and by implication the annual lambing rate was higher than the kidding rate. Breeding rams and bucks were found in 50% and 25% respectively of the flocks surveyed. The remaining flocks had no breeding males.

Since breeding is not controlled, none of the farmers interviewed could guess the age of their animals at first parturition and neither could they tell the intervals between parturition. Most of them were agreed that first lambings/kiddings produce mainly single births whereas twins were more frequent in subsequent births. There are also occasional triplet births. The data in Table 7 indicates that single births are more frequent in goats than in sheep ($P < 0.05$). Conversely, twin births are more frequent in sheep than in goats ($P < 0.05$). The difference in the frequency of triplets in sheep and goats was not significant.

Table 7 Frequency of singles, twins and triplets in sheep and goat flocks

	Frequency	
Type of birth	Sheep	Goats
Singles	41%	59%
Twins	50%	36%
Triplets	9%	5%

Offtake rate

The number of animals sold or consumed annually by the 115 farmers interviewed is shown in Table 8. Generally more male than female animals are sold or consumed.

Table 8 Number of animals sold or consumed annually by 115 farmers in Momo and Mezam divisions.

Class	Number of animals Sold		Consumed	
	Sheep	Goats	Sheep	Goats
Rams or Bucks	14 (4%)	29 (3%)	20 (6%)	31 (3%)
Ewes or Does	11 (3%)	82 (7%)	12 (4%)	20 (2%)
Lambs or Kids	2 (1%)	44 (4%)	8 (2%)	1 (0.1%)
Castrates	-	51 (4%)	-	23 (2%)
Male:Female ratio (approximately)	1.3:1	1:1	1.7:1	2.7:1
Total	27 (8%)	205 (18%)	40 (12%)	75 (7%)
Total small ruminants	232 (16%)		115 (8%)	
Grand Total	347 (23%)			

Male animals of both species are favoured for disposal since most of the females are retained in the flock for breeding purposes. Mainly entire male sheep are sold or slaughtered whereas castrates generally constitute the majority of male goats sold or slaughtered. The castration of male goats earmarked for sale is carried out at quite an early age and most of them are sold while they are still only kids (under one year of age). Castrated sheep, on the other hand, are retained in the flock much longer and may be used as a source of meat at non-Moslem feasts or used for some other purpose as the need arises.

The offtake rate calculated for sheep and goats in this survey were 20% and 24% respectively (flock mean percentages were 26 and 23 for sheep and goats respectively) with considerable variation between individual farms and systems of management (Table 9). The highest offtake rates were recorded under tethering/semi-extensive and extensive/extensive management systems.

Table 9 Offtake rate for sheep and goats under different management systems in the North West Province of Cameroon

Management system	Parameters	Sheep	Goats
Tethering/tethering	No. of animals	88	434
	No. of flocks	8	48
	% offtake	9	24
	Flock range	0-50	0-67
	Flock mean % offtake	13	20
Tethering/semi-extensive	No. of animals	55	396
	No. of flocks	9	34
	% offtake	35	28
	Flock range	0-44	0-65
	Flock mean % offtake	41	26
Tethering/extensive	No. of animals	35	177
	No. of flocks	6	20
	% offtake	23	20
	Flock range	0-38	0-80
	Flock mean % offtake	21	26
Semi-intensive/semi-intensive	No. of animals	103	93
	No. of flocks	2	2
	% offtake	3	30
	Flock range	0-15	0-32
	Flock mean % offtake	8	16
Semi-intensive/semi-extensive	No. of animals	-	47
	No. of flocks	-	1
	% offtake	-	2
	Flock range	-	-
	Flock mean % offtake	-	2
Extensive/extensive	No. of animals	59	-
	No. of flocks	2	-
	% offtake	48	-
	Flock range	26-71	-
	Flock mean % offtake	49	-
Total	No. of animals	340	1147
	No. of flocks	27	105
	% offtake	20	24
	Flock range	0-100	0-80
	Flock mean % offtake	26	23

Mortality

The mortality rates in sheep and goats under traditional management based on 105 completed questionnaires from goat farmers and 27 from sheep farmers are presented in Table 10. The mortality rates were not significantly different in either young animals (17.1% and 14.3% in lambs and kids respectively) or in adults (16.9% and 10.6% in adult sheep and goats respectively). The overall mortality rate was significantly higher in sheep than in goats ($P < 0.01$) even though the difference in flock mean percentage mortality rates was not significant. Significantly more sheep died in Momo than in Mezam ($P < 0.01$).

Table 10 Mortality rate in village sheep and goats

Mortality in	Parameter	Number of animals, mortality and flock range					
		Sheep			Goats		
		Momo	Mezam	Combined	Momo	Mezam	Combined
Lambs/ Kids	No. of animals	69	33	102	140	218	358
	% mortality	64	12	47	24	18	21
	Flock range	0-100	0-100	0-100	0-100	0-100	0-100
	Flock mean %	35	9	17	15	14	14
Adults	No. of animals	98	140	238	321	468	789
	% mortality	41	14	25	10	17	14
	Flock range	0-77	0-67	0-77	0-75	0-93	0-93
	Flock mean %	26	13	17	11	11	11
Total	No. of animals	167	173	340	461	686	1147
	% mortality	50	14	32	15	17	16
	Flock range	0-84	0-67	0-84	0-60	0-86	0-86
	Flock mean %	30	14	19	13	13	13

There were marked variations in mortality reported by individual farmers with rates ranging from 0 to 100 (Table 11). There was some suggestion of a higher mortality rate under semi-intensive/semi-intensive and semi-intensive/semi-extensive management systems with rates above 35% recorded in lambs and kids with flock mean percentage rates above 25%. Under tethering/tethering management systems, sheep appeared to have a slightly lower mortality (11% in sheep as against 17% in goats) even though the flock mean percentage rates were similar. On the other hand, under the tethering/semi-extensive system of management, goats had a significantly lower mortality rate than sheep ($P < 0.05$). The difference in flock mean percentage rate was not significant.

Table 11 Mortality rate under different management systems

Management system	Parameters	Sheep			Goats		
		Lambs	Adults	All stock	Kids	Adults	All stock
Tethering/tethering	No. of animals	27	61	88	133	301	434
	% mortality	11	11	11	25	14	17
	Flock range	0-67	0-67	0-67	0-100	0-75	0-60
	Flock mean % mortality	11	16	16	18	10	13
Tethering/semi-extensive	No. of animals	4	51	55	141	255	396
	% mortality	25	24	24	11	11	11
	Flock range	0-100	0-43	0-38	0-75	0-50	0-43
	Flock mean % mortality	11	17	18	9	12	13
Tethering/extensive	No. of animals	14	24	38	54	117	171
	% mortality	29	13	18	24	27	26
	Flock range	0-100	0-33	0-50	0-100	0-93	0-86
	Flock mean % mortality	10	13	20	13	9	13
Semi-intensive/semi-intensive	No. of animals	48	55	103	19	74	93
	% mortality	83	55	68	47	0	10
	Flock range	0-91	0-77	0-84	0-53	-	0-10
	Flock mean % mortality	45	38	42	26	0	5
Semi-intensive/semi-extensive	No. of animals	-	-	-	11	36	47
	% mortality	-	-	-	36	25	28
	Flock range	-	-	-	-	-	-
	Flock mean % mortality	-	-	-	36	25	28
Extensive/extensive	No. of animals	12	47	59	-	-	-
	% mortality	0	19	15	-	-	-
	Flock range	-	-	14-16	-	-	-
	Flock mean % mortality	0	19	15	-	-	-

The causes of most mortalities reported by the farmers were rather speculative. In this report only diseases and ailments known to the sheep and goat farmers are considered. The frequency of reports for these various signs of disease is shown in Table 12. The two main disease signs in sheep and goats were diarrhoea and tick infestation. Other signs observed were probably associated with important disease problems like pneumonia, peste des petits ruminants and nasal botfly infestation.

Table 12 Normal signs associated with morbidity and case mortality in village sheep and goats

Signs of disease	Morbidity (%)		Case mortality (%)	
	Sheep	Goats	Sheep	Goats
Sudden death	–	–		1
Mange	28	49		3
Ticks	73	71	24	4
Lice	15	17		
Difficult delivery	11	10		0.3
Diarrhoea	81	70	22	20
Sore mouth	17	32		1.0
Nasal discharges	69	68	7	16
Salivation and foaming at the mouth	25	19	7	8
Coughing	63	78	7	4
Conjunctivitis (pink eye)	33	24		4
Emaciation	69	58		1
Loss of appetite	13	29		8
Abortion	40	38		
Mastitis	13	14		
Lameness	30	17		
Bottle jaw	35	18		
Accident	–	–	7	10
Strangulation	–	–	7	3
Poison	–	–		3
Weakness	–	–		4
Helminthiasis	–	–		2
Oestrus ovis	–	–		0.3
Predation	–	–	2	–
Cause unknown	–	–	15	14.0

If the prevalence of disease is considered in relation to the management system, it is observed that death by strangulation occurred only in systems that involved tethering of animals at some stage. Death is caused by asphyxiation as a result of the tether being too tight round the neck of the animal as may happen if the animal gets entangled and then struggles to free itself. Cases of tick infestation and diarrhoea were reported under all

management systems and were particularly common during the rainy season. Deaths from accidents were more frequent when tethering/semi-extensive and tethering/extensive systems were used than occurred under the systems which restricted animal movement throughout the year.

Disease control

Deliberate attempts to control disease in traditionally managed village flocks are not very common. Only about 17% of the farmers interviewed in Mezam and 4% of those interviewed in Momo make use of the veterinary

Table 13 Traditional treatment of diseases in small ruminants

Traditional formulae of drug (concoction)	Disease or symptom against which the concoction is directed
1) Waste engine oil or kerosine plus palm oil	Mange, sore mouth, wounds, ticks
2) Palm oil alone or mixed with Izal	Mange
3) Salt	Salivation, recumbency
4) Salt plus M & B (760) (sulphathiazole)	Peste des petits ruminants
5) Aspirin or M & B (760) or tetracycline capsule	Treatment of all diseases
6) Soot mixed with salt	Diarrhoea and whenever the animal shows any sign of illness
7) Various combinations of special grasses and leaves either squeezed and given to the animal to drink or burned and ground into a black powder	Diarrhoea, mange, snake bite

services in their locality on a more or less regular basis. Over 60% of the farmers interviewed in the two divisions had never sought veterinary assistance even though over 84% of them live within 10 km of the nearest veterinary clinic. The main reason why very few farmers attempt veterinary treatment of their sick animals is that the drugs are expensive and most of them do not consider that the cost of the drugs is commensurate with the value of the few animals which they keep, essentially as a sideline source of income.

The use of traditional medicine for the treatment of sick animals is

practised on a very small scale (18%) with very limited success. The various treatments that have been attempted are summarised in Table 13.

Economics of small ruminant production

About 60% of the farmers in Momo and Mezam derive less than 10% of their income from sales of sheep and goats; 25% of them derive between 10-25%. Only about 6% actually depend on small ruminants as their main source of income.

The majority of village sheep/goat rearers (67%) sell their animals in the local markets, usually located within walking distance from their homes. The principal buyers are itinerants or middlemen who seek to buy the animals at a cheaper price than local consumers as they intend to retail in the big towns at a profit. Occasionally the farmer may sell the animals at home either to other farmers for breeding purposes or for consumption.

Sheep and goat sales increase before festivals that involve feasts such as Moslem feasts and Christmas.

Constraints to small ruminant production under traditional management

The main constraints as seen by the farmer include the following factors:-

(1) Daily management of stock relies mainly on cheap family labour. Labour problems arise when the children grow up and go either to college or to work away from home.

(2) Tethering is a very laborious process especially when family assistance is not available and the owner has to do it all by himself.

(3) The fear of the animals being stolen necessitates tethering close to the house and good pastures may not be available in the immediate vicinity. The consequence is poor growth performance and emaciation and possibly high mortality resulting from malnutrition and the increased risk of helminth infections.

(4) The fear of theft is also a limiting factor determining the number of animals a farmer can keep at any particular time.

(5) Tethered animals get entangled easily and may be strangulated before they can be rescued.

(6) Available grazing land is continuously being reduced by the encroachment of cultivated land through intensification of agriculture and this, coupled with the scarcity of good pastures during the dry season, further limits the number of animals a farmer can keep.

(7) The not too infrequent confrontation between livestock owners and

crop farmers compels most stock farmers to reduce their stock to a number they can conveniently manage properly.

(8) Many stockowners have off-farm work of some sort. The nature of a stockowner's off-farm work (especially when it involves his staying away from home all day) may not permit him to be personally involved with the routine care of his animals most of the time and this may have an overall effect on production.

(9) A shortage of capital prevents many people from starting, expanding or improving their management facilities.

(10) Night sheds for animals are often so poorly constructed as to make cleaning difficult. The result is an accumulation of faeces and urine to such an extent that it can create a probable health risk.

(11) Veterinary care for small ruminants in the province is still minimal. Since very few farmers attempt any treatment of sick animals, mortality is high, up to 100% in some flocks. This situation puts some people out of small ruminant production and compels many others to greatly limit their flock size.

(12) The link between the veterinary services in the rural areas and the small ruminant farmers is weak. The result is that disease problems including epidemics often go unattended resulting in high mortalities.

DISCUSSION

There is clearly a greater emphasis on goat than on sheep production in Momo and Mezam divisions of the North West Province of Cameroon. A similar but less marked situation was reported in Southern Nigeria by Matthewman (1980) who found that 50% of households owned goats as against 22% who owned sheep. The traditional belief connecting sheep keeping to a woman's fertility is perhaps the greatest restraint to sheep production in these two divisions. There is no evidence of a similar belief anywhere else in the tropics. Thus it is simply a cultural idea of the people, and has no scientific explanation.

It was observed that somewhat more people in Mezam than in Momo division keep sheep. The probable reason for the presence of more sheep farmers in Mezam is the larger Moslem population in this division, mutton being the preferred meat at Moslem feasts.

The small flock sizes observed is typical of small ruminant production in the developing countries. Matthewman (1980) recorded mean flock sizes of 3.5 goats and 2.5 sheep per holder in Southern Nigeria. Sumberg (1985) reported average flock ranges of 2-5 animals per owner for the same region,

with goats being more common than sheep. The tendency for larger flock sizes in mixed flocks was also observed by Wilson (1983) for the forest zone of Africa (goats only 2.8, sheep only 2.0, mixed flocks 5.1).

The preponderance of female animals in the flock confirms with Wilson (1980, 1983) who observed that overall females make up more than two-thirds of the flocks. He gave a range of 75-80% females in a flock under normal socio-economic and ecological factors in the semi-arid areas of Africa; 80% of females in the derived savanna areas and 83% in the true forest areas. Wilson (1982) noted that whatever is the main economic objective in keeping sheep or goats, there is a remarkable similarity in flock structure across the whole of the semi-arid zone with the flocks having around 75% females and somewhere in the region of 55% of the total flock being breeding females over 12 months of age. We may infer from the findings in this study that these observations are probably also true of the savanna zone.

It was noted in this survey that the male:female ratio for sheep was 1:4 in Momo as against 1:11 in Mezam. This may be explained by the fact that since only relatively few people in Momo keep sheep, most of them own their own breeding rams as individual flocks may not be readily accessible to each other even when on free range. The smaller proportion of bucks compared to rams may then be attributed to the fact that there are more goat flocks than sheep flocks. The more or less even distribution of the breeding bucks in the flocks makes accessibility to them easy because a farmer can borrow from a neighbour or else have his animals bred during the non-cropping season when they are on extensive grazing so that the whole population of goats in a village behaves as a single inter-breeding flock.

Tethering/tethering and tethering/semi-extensive are the most widely practised management systems of small ruminants since most rearers utilize a very low level of mostly unpaid family labour (children, wives and relatives) for tethering the animals and this reduces the tediousness of the system. Security against theft or accident is ensured and confrontation with crop farmers is avoided. Even when the animals are on semi-extensive management, they are usually locked in at night by the owner, who counts them to ensure that all had returned. Moreover these two management systems fit conveniently into the cropping patterns and with the limitation of grazing land. Systems of management that necessitate confinement of animals in fenced paddocks, even during part of the year, require a high initial cash input, adequately constructed fences and watering facilities, provision of

supplementary feed including agro-industrial by-products and treatment against common ailments. These requirements are not easily met by the small scale subsistence farmers and hence such systems are not widely practised. The almost complete lack of veterinary care often results in high mortality. Extensive management either throughout or during part of the year which allows for maintenance of larger flocks is not very popular because of the greater risk of animals going missing through straying, theft or predation. The system also requires availability of extensive non-arable grazing land preferably delineated by natural boundaries so that there is no farmer-grazier confrontation. Tethering of the animals at least during part of the year is therefore preferred since, although it is labour intensive, the animals are relatively secure against theft and the extremes of weather changes through easier control.

The time when animals are sent out for grazing is important, especially from the parasitological point of view. The critical morning period is when dew is still present on grass blades. Infective larvae of trichostrongyles migrate from the soil and faeces to the herbage in response to light when moisture conditions are suitable, particularly when early morning dew is present (Skerman and Hilliard, 1966). In this respect 9.00 a.m. appears to be an optimal time for sending out animals during the wet season. Sending out the animals later does not appear to be appropriate as the few hours of grazing time allowed do not give the animals sufficient time to graze/browse before the day is over. Moreover, the animals need time in between grazing to ruminate and so the longer the time they are on pasture, the better. Early grazing of animals during the dry season appears more justifiable since the risk of picking up helminth infective larvae during this period is minimal. It is also beneficial to the animals if they are allowed as much time as possible to graze before the sun becomes too intense.

Housing the animals in an enclosed shed with a raised slatted floor is ideal for the village situation where frequent cleaning of the faeces may not be feasible. Lifting the animals off their faeces and urine will help prevent reinfestation from internal parasites including coccidia and helminths. Adequate housing for animals confers several other advantages as it:-

(a) Provides the opportunity for closer control of feeding, disease and breeding.

(b) Protects the animals from rain, excessive heat, wind, cold and drought.

Breeding is generally uncontrolled in the village flocks and indiscriminate matings of young animals are bound to occur with possible disadvantages for body development, reproductive performance and life time productivity (Peters *et al.*, 1981). The low kidding rate reported for goats may be attributed to the tethering practised by most stock owners during the cropping season. Since most goat flocks have no bucks, tethering for about six months in a year (March to August) means that breeding does in the flocks that do not have breeding bucks are usually only exposed to males between September and February, when the animals are on free range. This only allows for the possibility of one kidding in a year. On the other hand, most sheep flocks have their own rams and so breeding can take place any time in the year making it easier to have two lambings in a year. The Grassland Dwarf sheep and goats are non-seasonal breeders so both have the potential for two lambings/kiddings (Peters *et al.*, 1981; Oppong and Yebuah, 1981) but this can only be achieved under good management. Goats have been shown to be superior to sheep in reproductive performance with a higher birth rate, high twinning rate and higher level of survival after the first week of life (Wilson, 1976; Matthewman, 1977). This, in effect, means that the full reproductive potential of the goats is not being realized under the management systems practised in the North West Province of Cameroon. Peters *et al.* (1981) outlined the following managemental factors which limit the effective rate of reproduction:-

(1) Uncontrolled mating.

(2) Inbreeding

(3) An insufficient level of nutrition for lactating ewes and does.

(4) Insanitary conditions in sheds especially for newly born lambs and kids.

(5) Inadequate disease control and disease prevention measures.

All of these factors are present in most flocks in North West Province of Cameroon.

Flock productivity can be assessed by determining the rate of offtake or extraction, both of which give a reflection of reproduction and production performance, mortality and selling age. Offtake is defined as the number of animals that leave the flock each year (for whatever reason) as a percentage of flock size. Offtake is equal to the extraction rate when it is assumed that there is no change in the flock size. However, if cognizance is taken of the

changes in flock size, the extraction rate is then calculated as the changes in the flock inventory during the previous year plus the number slaughtered as a proportion of the total flock (Fowler, 1981). Since flock inventory was carried out only once in the present survey, offtake rates are used as a measure of productivity and calculated as follows:-

$$\text{Offtake} = \frac{\text{No. of animals sold + No. consumed + No. given for social reasons}}{\text{total flock}} \times 100$$

Offtake rates of 20% for sheep and 24% for goats, with flock mean rates of 26% and 23% respectively, observed in North West Province of Cameroon are similar to that of 27% for goats found in low income economic units in West Malaysia by Peters *et al.* (1981) who also noted considerable differences with the type of economic unit and system of management. The high offtake rates of 35% and 28% for sheep and goats respectively under tethering/semi-extensive and 48% for sheep under extensive/extensive management systems may be attributed to the fact that these systems allow for maintenance of larger flocks at least during the non-cropping season since labour requirements and health risks are low. In the tethering-semi-extensive system many of the adults in the flock are sold before the beginning of the cropping season. Under extensive/extensive systems the farmer disposes of the animals as soon as they attain a reasonable size (about 10-15 kg liveweight) as a safeguard against loss through theft, straying or predation.

The generally low offtake rates in the North West Province of Cameroon may be explained by the fact that sheep/goat rearing is undertaken as a family tradition, handed down from father to son and is seen as an indication of property owned, only to be disposed of at times of absolute necessity. Small ruminant production is thus only a sideline activity, carried out in addition to the main source of income which is usually agronomy, to provide a flexible source of capital.

The difference in the mortality rates between lambs/kids and adults was very small, probably insignificant. The variation in the mortality reported by individual farmers in this study may be attributed to managemental variations between households or it may be the effect of some epidemiological characteristics of the primary diseases causing death (Mack *et al.*, 1985) which requires a further study. Peters *et al.* (1981) recorded an average loss rate in kids of 14.3% which agrees with the observations in this report. Their reported loss rate of 22.7% under the tethering system is also within the range of that recorded in this study.

Tick infestation and diarrhoea were considered to be among the major causes of death. Ticks cause losses in small ruminant production not only by causing mortality but also through their blood consuming activity and their ability to transmit viral, protozoal and other diseases (Hall, 1977).

Diarrhoea in both sheep and goats can be of various origins. Thus it can be viral (e.g. the rotaviruses) or bacterial (e.g. neonatal diarrhoea of lambs and kids caused by the enteropathogenic strain of *Escherichia coli* [collibacillosis] or occasionally by *Clostridium perfringens* type B and C [lamb dysentery]) (Siegmund, 1973). Diarrhoea is also one of the main clinical features of nematode infestations in sheep and goats. Furthermore, diarrhoea, along with conjunctivitis coupled with ocular discharge, salivation and foaming at the mouth, mouth sores, nasal discharges and other symptoms of pneumonia are signs of peste des petits ruminants (Obi, 1980).

Bronchopneumonia is characterized by coughing and nasal discharges as some of the signs.

On the basis of the above analysis and the findings in the epidemiological study on parasitic gastro-enteritis in village animals, one can identify five main disease problems of sheep and goats in the North West Province of Cameroon, namely:- intestinal parasitism (especially helminthiasis), tick infestation and the viral diseases associated with it, pneumonia (bronchopneumonia and pleuropneumonia), peste des petits ruminants and *Oestrus ovis* infestation. Whereas intestinal parasitism, tick infestation and pneumonia are endemic, peste des petits ruminants is an epidemic disease that has been known to destroy whole flocks.

Disease treatment in village flocks using various local concoctions will have met with little success, if any, and cannot be relied upon as a means of treating a sick sheep or goat.

Small ruminant production in the traditional sector in North West Province of Cameroon is mainly implemented with zero-cost means as farmers provide no special feed, housing, veterinary care or other inputs and production is risky due to a high mortality. The animals constitute a sort of savings account which can be drawn upon in times of need. Estimates of potential income for the farmer from small ruminants reveal that the animals contribute very little to the income of the owner.

Improvement of village sheep and goat production

Improvements in village sheep and goat production might be achieved by changes in management and husbandry practices. The main areas for

attention should be nutrition, health, management, breeding and marketing.

Effective extension programmes are needed to demonstrate the benefits that can be achieved from improved feeding. Improvements in feeding may have an impact on disease susceptibility and therefore on mortality. Harvest by-products should be preserved for supplementary feeding during the dry season. Browse and fodder should be provided whenever pastures that are being grazed are poor. Farmers are encouraged to develop plots of Guatemala grass for dry season supplementary feeding.

Some minimal input of veterinary disease control is necessary. Village veterinary clinics should be stocked with basic drugs against common disease problems and retailed to farmers. Veterinary field staff and personnel of other government services involved with extension should make a greater effort to increase contact with farmers. Since many disease problems can be controlled or even prevented through proper management, a close collaboration between the extension services and the farmers can considerably increase potential returns from small ruminant production.

Epidemics like peste des petits ruminants should be promptly and adequately controlled through government intervention.

Deworming campaigns should be intensified as worm infections are probably a major cause of unthriftiness and mortality in village animals. Three prophylactic treatments given in December, May and July may be effective (under village conditions) in keeping the worm burdens in animals low throughout the year.

Reproductive performance can be improved through controlled breeding. An average of three lambings/kiddings in two years would be ideal for optimum productivity. The separation of sexes inside the shed and early castration of males not needed for reproduction are essential if inbreeding and early conception by immature females is to be avoided. Individual farmers are encouraged to own their own rams/bucks which must be changed every two years to avoid inbreeding. Alternatively there could be a regular exchange of breeding rams/bucks among farmers.

Animals must be provided with adequate housing which should be constructed with a view to facilitate removal of faeces. A suitable housing system is one with a raised slatted floor which should be cleaned at least once every two days.

More potential returns from small ruminant farming can be obtained by restricting flock size to shed capacity, early culling and selling of old or

unreproductive females and males not required for breeding.

Specific production problems within each climatic zone connected with nutrition, health management and breeding should be investigated through on-farm research. Appropriate advice should then be given encompassing three primary aspects as proposed by Brunsdon (1980):-

(1) Explanation of the basic principles and rationale involved.

(2) Proposal of a model scheme and an outline given of the various ways and means by which the objectives may be achieved.

(3) Suggestions of a number of permissible compromise procedures which would overcome foreseeable management difficulties.

It would then remain the responsibility of the farmer to establish within the suggested guidelines the most practical procedure appropriate to his particular management system.

In the words of Matthewman (1980) it may be concluded that any changes in the village system should aim at maximising the efficiency of the present resource utilization before going to more land and labour-intensive systems of production.

SURVEY ON HAEMOGLOBIN POLYMORPHISM IN LOCAL

BREEDS OF SHEEP AND GOATS

MATERIALS AND METHODS

A study of the haemoglobin variants in Cameroon breeds of sheep and goats was conducted in the North West Province of Cameroon during the first half of 1987. The haemoglobin types of 278 sheep (260 Grassland Dwarfs and 18 Fulani Bornu) and 232 goats (198 Grassland Dwarfs and 34 Red Sokoto) were determined.

Haemoglobin preparation

A haemolysate of each blood sample was prepared by the method described by Kohn (1970).

Electrophoretic technique

Electrophoresis was carried out in a tank designed particularly for cellulose acetate membrane (CAM) electrophoresis on CAM strips, 77 x 150 mm (Shandon Scientific Co. Ltd., London), by the method recommended on the manufacturer's instrument application notes (Kohn, 1970). The buffers used were 0.26M TRIS buffer (pH 9.1) at the anode and 0.05-0.07M barbital buffer (pH 8.6) at the cathode. A 5µl automatic micropipette was used to apply samples of haemolysed blood to the numbered areas on a sample plate and then transferred by means of a multi-applicator (Shandon Scientific Co. Ltd., London) to the buffer-impregnated and blotted cellulose acetate membrane sheet in the electrophoresis tank. Using a 250V stabilised power supply from a VOKAM power supply unit (Shandon Scientific Co. Ltd., London), the electrophoresis was run for one hour.

The strips were fixed in 5% trichloroacetic acid, stained for 15 minutes in 0.2% solution of Ponceau S in 3% trichloroacetic acid and washed in three changes of 5% acetic acid for 5, 5 and 10 minutes respectively. The strips were blotted free of excess moisture between three changes of filter paper and finally dried between fresh sheets under pressure overnight.

RESULTS

Three adult haemoglobin variants (HbA, HbB and HbC) of distinctly different mobilities were identified and their electrophoretic patterns are demonstrated in Plates 6-9. Haemoglobin A had the fastest mobility and haemoglobin C the slowest mobility towards the anode; haemoglobin B was intermediate in behaviour. Haemoglobin types A and B occurred in sheep

Plate 6 Haemoglobin types of Grassland Dwarf sheep

a, b, c, d - Hb type AB
e, f, g, h - Hb type B
i, j - Hb type C

Plate 7 Haemoglobin types of Grassland Dwarf goats

a, b, c, d, e, f - Hb type B
g, h - Hb type BC
i, j - Hb type C
(samples a, b, c and d are from nursing kids)

Plate 8 Haemoglobin types of Red Sokoto goats

a, b, c, d - Hb type B
e, f, g, h - Hb type BC
(samples g and h are from nursing kids)

Plate 9 Comparison of electrophoretic patterns of haemoglobin types in Grassland Dwarf sheep and goats and Red Sokoto goats

Red Sokoto goats: a, b - Hb type B
c, d - Hb type BC
Grassland Dwarf sheep: e, f - Hb type AB
g, h - Hb type B
Grassland Dwarf goats: i - Hb type C
j - Hb type BC
k, l - Hb type B
(sample d is from a nursing kid)

(Plate 6) while haemoglobin types B and C were found in goats (Plates 7 and 8). The mobility of the HbB type was the same in sheep and goats (Plate 9).

Table 14 Genotype frequencies of haemoglobin types in some Cameroon indigenous sheep

Breed	Class/sex	Genotype frequencies		No. of animals examined
		HbAB	HbBB	
Grassland Dwarf	Males:			
	Lambs	0.11	0.89	28
	Rams	0.04	0.96	45
	Total	0.07	0.93	73
	Females:			
	Lambs	0.11	0.89	36
	Ewes	0.08	0.92	151
	Total	0.09	0.91	187
	All lambs	0.11	0.89	64
	All adults	0.07	0.93	196
	All stock	0.08	0.92	260
Fulani Bornu	Ewes	0.06	0.94	18

The genotypic frequencies found for sheep are shown in Table 14. The gene frequencies of the A and B alleles were 0.08 and 1.00 in Grassland Dwarf sheep and 0.06 and 1.00 in the Fulani Bornu respectively. The frequencies of phenotypes HbAB and HbBB were similar in the two breeds.

The genotypic frequencies found for goats are shown in Table 15. The results indicate that in the Grassland Dwarf goats the gene frequencies of the B and C alleles were 1.00 and 0.15 respectively. In the Red Sokoto goats ("Rousse") the frequencies of the B and C genes were 1.00 and 0.38 respectively. The heterozygote BC had a higher frequency in the Red Sokoto goats than in the Grassland Dwarf goats ($P < 0.001$).

In nursing kids of about 2-3 months of age, the B zone appeared broader and showed an indistinct demarcation into two bands, the more cathodal band lying in the normal position for the HbB (Plate 7). The forward band may represent the remains of the F haemoglobin in transition to the adult haemoglobin type.

Chi-square analysis showed no significant differences in the phenotypic

and gene frequencies between young animals and adults and between males and females of each breed of sheep and goats.

Table 15 Genotype frequencies of haemoglobin types in some Cameroon indigenous goats

Breed	Class/sex	Genotype frequencies HbBB	HbBC	No. of animals examined
Grassland Dwarf	Males:			
	Kids	0.85	0.15	34
	Bucks	0.75	0.25	8
	Total	0.83	0.17	42
	Females:			
	Kids	0.82	0.18	65
	Does	0.88	0.12	91
	Total	0.85	0.15	156
	All kids	0.83	0.17	99
	All adults	0.87	0.13	99
	All stock	0.85	0.15	198
Red Sokoto "Rousse"	Males:			
	Kids	0.58	0.42	12
	Bucks	1.00	-	1
	Total	0.62	0.38	13
	Females:			
	Kids	0.80	0.20	10
	Does	0.45	0.55	11
	Total	0.62	0.38	21
	All kids	0.68	0.32	22
	All adults	0.50	0.50	12
	All stock	0.62	0.38	34

Three animals, a Grassland Dwarf lamb and kid and a Red Sokoto doe, showed abnormal haemoglobin types (Plates 6 and 7) with mobilities similar to the haemoglobin type HbC described for goats. The Grassland Dwarf lamb and kid had been under an experiment in which 7.5 ml of blood was collected weekly for haematology. The lamb was infected daily seven times a week with 200 L_3 of *Haemonchus contortus* while the kid was a control (no infection) in that study. Their haemoglobin types had been determined before the commencement of the experiment and 20 weeks after. The Grassland Dwarf lamb originally carried HbB but this zone disappeared in the production of the abnormal HbC. The "C" zone in this animal consisted of two bands, a stronger backward and a weaker forward band. The kid originally carried HbBC (Plate 7) but the B zone disappeared when the abnormal HbC was formed.

DISCUSSION

The haemoglobin types A and B observed in this study have been

widely reported in sheep (Harris and Warren, 1955; Cabannes and Serrain, 1955; Evans *et al.*, 1956, 1957, 1958; van der Helm *et al.*, 1957; Templeton *et al.*, 1972; Olusanya, 1975; Schillhorn van Veen and Fularanmi, 1978) and goats (Khanolker *et al.*, 1963; Huisman *et al.*, 1967; Adams *et al.*, 1968, 1969; Wrightstone *et al.*, 1970; Joshi *et al.*, 1975; Goel and Nair, 1976; Singh *et al.*, 1977; Baruah and Bhat, 1980; Fesus *et al.*, 1983; Bhat, 1986). These are the usual haemoglobin types found in sheep and goats. Relatively few investigators have examined the electrophoretic patterns of the haemoglobin types in sheep and goats on a comparative basis. Harris and Warren (1955) investigated the electrophoretic behaviour of adult haemoglobins of sheep and goats but did not specify whether the "relatively fast moving" and "slow moving" haemoglobin types they identified migrated at the same rate in the two species. However, Cabannes and Serrain (1955) in their study included some illustrations which showed that the fast haemoglobin type in goats had a similar electrophoretic behaviour as the slow haemoglobin type in sheep. Comparing these illustrations to the observations in the present study, the haemoglobin types they identified as fast and slow in sheep probably correspond to the haemoglobin types A and B respectively in this study. On the other hand, the fast and slow haemoglobin types they identified in goats appear to correspond to the haemoglobin types B and C in the present study. In the present study type B appears to be in the same position in both species so it is logical that they should be named the same. However, a comparative study on the structures of these haemoglobin types in sheep and goats would be desirable in a future investigation.

The rare haemoglobin type HbC observed in this study is of potential interest. It is suggested that the change in haemoglobin type to HbC might have occurred in response to haematological stress. In the lamb it was probably a result of both haemonchosis and the weekly bleeding. In the kid which was a control, weekly removal of only 7.5 ml of blood was not enough to have caused sufficient haematological stress. This requires further study.

Haemoglobin type HbC has been described by several investigators from sheep subjected to the stress of severe anaemia resulting from experimental bleeding or other causes (Blunt and Evans; 1963; van Vliet and Huisman, 1964; Braend *et al.*, 1964; Blunt, 1965). It has been observed in normal sheep as well (Efremov and Braend, 1966). It has been shown to occur only in sheep with phenotypes AA and AB and to be absent in BB sheep even under anaemic conditions. The electrophoretic pattern described for this

haemoglobin type agrees with the observations in this survey. However, contrary to the reports in the literature on the source of HbC, the lamb in this survey which carried the HbC originally had HbB before the change occurred.

Haemoglobin type HbC has also been reported from goats but unlike sheep, it was found to be normally present in small amounts in all non-anaemic individuals, and anaemic HbA, AB and B animals produced it with identical patterns (Tucker *et al.*, 1983). The present survey also found that HbC is a normal occurrence in goats, but not in all goats, and could be formed under stress conditions as well as from HbB. The electrophoretic pattern for this haemoglobin type was identical to the HbC found in sheep. It would appear that the HbC observed in goats in this study is different from the HbC reported by Tucker *et al.* (1983) who described it as a distinct band ahead of the more anodal A zone. Some further study of the haemoglobin structure of the HbC observed in the present investigation is necessary to confirm its identity.

The electrophoretic patterns described for Nigerian goats by Enyenihi (1974) and Buvanendran *et al.* (1981) can be compared, using conventional letter symbols, to the observations in this survey. The fast haemoglobin type which these workers designated as HbF appears to correspond to HbA and was not seen in the goats examined during this survey. Similarly HbN (normal) and HbS (slow) probably correspond to HbB and HbC respectively. The controversy over the exact position of HbC in relation to the other haemoglobin types of goats requires further investigation. Nevertheless, evidence from this survey suggests that Cameroon goats and sheep in the savanna zone produce an HbC with an identical migration in cellulose acetate electrophoresis. In sheep it occurs only under severe stress conditions such as anaemia induced by experimental bleeding whereas in goats it is of normal occurrence and can also be produced in anaemia.

The present study has established a frequency of 1.00 for the B gene in Cameroon sheep and goats in the North West Province. Schillhorn van Veen and Fularanmi (1978) also reported a gene frequency of 1.00 for HbB in Northern Nigerian sheep. The gene frequency for HbA obtained in the present survey was 0.09 in the Grassland Dwarf sheep and 0.06 for the Fulani Bornu, the latter conforming with the figure of 0.06 reported by Evans *et al.* (1958) for Fulani breeds from Cameroon. Olusanya (1975) reported a gene frequency for HbA of 0.693 in dwarf sheep in Ibadan located in the forest zone of Nigeria. In British breeds of sheep, it has been observed that lowland breeds are

predominantly of haemoglobin type B while haemoglobin A is very much more conspicuous in the mountain and hill breeds (Evans *et al.*, 1957). Templeton *et al.* (1972) in the U.S.A. provided evidence that HbA alleles may have a selective advantage at high altitudes. In goats, it has been observed that most of the world's breeds are either fixed for the HbA allele (Efremov and Braend, 1965; Crottaz, 1975) or with HbA frequencies considerably higher than those of HbB (Osterhoff and Ward-Cox, 1972; Crottaz, 1975; Milovan and Granciu, 1978; Fesus et al., *1983; Barbancho et al.*, 1984).

In the present investigation, the intense selection for the B gene in the population must be of some adaptive value in this geographical region or else it should not have been selected for in preference to the A gene. It would appear that whereas the A gene confers a genetic advantage to the animals in the forest zone, perhaps by conferring resistance against haemonchosis (Evans *et al.*, 1963; Evans and Whitlock, 1964), the B gene probably also confers some genetic advantage to the animals in the savanna zone for reasons which have yet to be defined. However, animals with HbB have been found in Australia and Britain to show better reproductive performance (King *et al.*, 1958; Evans and Turner, 1965), lower lamb mortality (Obst and Evans, 1970) and are probably more economic users of water and sodium (Michell, 1975). These are all important attributes in the savanna area.

PART III

EPIDEMIOLOGICAL STUDIES

INTRODUCTION

The epidemiological studies were intended both to examine the factors which predispose sheep and goats to helminth infections and their effects on production, and to evaluate the effectiveness of various control measures intended to increase production. The experiments designed permitted the collection of data on clinical, helminthological, climatological and production parameters.

MATERIALS AND METHODS

Location

The studies were carried out both at the Animal Research Station at Mankon and at Batibo. The research station is located on the outskirts of Bamenda in Mezam division (Figure 1) at an altitude of about 1000 m. The village of Batibo in Momo division, where the co-operating farmers for this study live, is located some 50 km south-west of Bamenda at an altitude of about 900 m (Figure 1).

Table 16 Percentage composition of sheep and goat supplement at Mankon

Feed item	Sheep diet	Goat diet
Corn	40.0	44.9
Rice bran	42.9	33.1
Cottonseed cake	15.0	20.0
Dicalcium phosphate	2.1	2.0
	100.0	100.0

Animals

The animals used for the studies were Grassland Dwarf sheep and goats and Red Sokoto goats (Plates 1-3). Tracer animals were aged between 3 and 6 months and had been reared indoors and fed on cut forage and concentrate containing 16-18% protein (Table 16) from about two weeks of age. Until they were weaned at 3 months, they were kept with their dams overnight to suckle. Faecal samples were collected from them at fortnightly intervals and examined for any evidence of helminth infection. If any animal was found infected, all were treated with Ivermectin at 200µg/kg body weight.

Grazing and Feeding Routine

The pastures at Mankon consisted principally of *Brachiaria* spp. (*B. ruziziensis* and *B. mutica*), *Melinis minutiflora*, *Stylosanthes guianensis*, *Hyparrhenia rufa*, *Cynodon dactylon*, *Setaria pallidesfusca*, *Imperata cylindrica* and *Aspelia* spp. (*A. africana* and *A. latifolia*). The principal herbage species on the pastures for sheep and goats on mixed grazing were *Hyparrhenia rufa*, *Melinis minutiflora* and *Imperata cylindrica*. Fodder species fed to all animals in hay racks during the dry season were principally Guatemala (*Tripsacum laxum*) and elephant grass (*Pennisetum purpurium*). The pastures had been grazed by the animals of the general stock before being utilized for this study. The animals were given approximately 0.25 kg each of a concentrate mixture of cottonseed cake, rice bran, corn and dicalcium phosphate containing 16–18% protein (Table 16) each morning before being sent out for grazing. Salt and water were provided *ad libitum*. The animals were not usually sent out for grazing before 9.00 a.m. to allow the dew to evaporate from the pastures.

The on-station traditionally managed animals grazed in a paddock containing mainly *Hyparrhenia rufa* and a few browse plants like *Ficus thonningii* and *Draceana arborea*. Between March and August or September when they were being tethered they were also fed elephant grass and *Melinis minutiflora*. They were additionally given browse fodder, mainly branches of avocado tree (*Persea* spp.) during the dry season. The traditionally managed animals at Batibo grazed on pastures containing green forage (mainly *Melinis minutiflora*, Pennisetum purpurium, Hyparrhenia spp., Aspelia spp. and Imperata spp.) and browse, which was abundantly available during most of the year. The browse plants included cassava (*Manihot esculenta*), gauva (*Psidium guajava*), bitter leaf herbs, avocado and other edible trees and shrubs with low branches. In addition they fed on crop residues (groundnut and bean haulms, corn stover, sweet potato vines, sugar cane tops, cassava leaves, plantain/banana leaves, etc.) and household waste (potato, cassava and yam peelings and peels of banana, pawpaw and mango, etc.). They were usually tethered during the cropping season (March to August or September) but left on free-range between September and February, once the crops had matured and been harvested.

Housing

The animals at Mankon were housed in aluminium-roofed cement block houses with wooden slatted floors which were cleaned daily. Housing for the

traditionally managed animals both at Mankon and in the village consisted of aluminium-roofed slatted-floor enclosures constructed of eucalyptus logs for the floor and a combination of raffia bamboos, tree fern and sticks for the walls (Plate 5).

Weather Records

Daily rainfall and air temperature (minimum and maximum) were read from equipment located at the research station. Readings were taken daily at 7.00 and 19.00 hours.

Liveweight Measurements

Liveweights were determined at Mankon using a clock-face spring balance, 0-50 kg range and at the CTVM using a Salter pocket balance No. 3, 0-25 kg range (Griffin and George, Loughborough, Leicestershire). The animals at Mankon were weighed between 7.30 and 8.30 a.m. while those at the CTVM were weighed between 9.00 and 9.30 a.m., and in both cases this was carried out before the animals were fed.

Faecal Egg Counts

Faecal egg counts were determined by a modified McMaster technique (Whitlock, 1948). Faecal samples were taken directly from the rectum of each animal between 7.30 and 9.30 a.m. The samples from the animals at Mankon were taken to the laboratory immediately and kept at -20°C until examined. Those from village animals were routinely taken to the laboratory as soon as possible in an insulated box containing ice blocks and frozen within six hours of collection.

Larval Cultures and Differentiation

Larval cultures for the experimental studies at the CTVM were carried out by the method described by Pullan and Sewell (1980). Those for the studies at Mankon were prepared by methods derived from those described by Whitlock (1956). The pellets were placed without packing in 500 ml glass jam jars which were closed loosely and kept in the dark at room temperature (16°C-27°C daily range) for 15 days. A little water was added as necessary to the faeces during incubation to maintain the correct consistency. After incubation, each jar was filled with lukewarm water (37°C) and left standing on a laboratory bench for 1-2 hours. During this period the larvae migrated from the faecal pellets into the fluid. The fluid was then poured through a domestic sieve onto Kleenex tissue (Kimberley-Clark Ltd., Maidstone, Kent) or other suitable tissue, which trapped the larvae while allowing the fluid to flow through. The larvae were then cleaned and concentrated by the Baerman

technique (Ministry of Agriculture, Fisheries and Food, 1979) and stored in clean labelled medical flat bottles laid horizontally at 4°C.

To identify the larvae, four drops of iodine were added to each ml of fluid. After a few minutes the larvae were examined under a compound microscope at x40. Specific identification of the larvae was carried out according to Skerman and Hilliard (1966) and the Ministry of Agriculture, Fisheries and Food (1979). The results were taken as indicating the proportion of the eggs of the different genera which were present in the faeces.

Pasture Larval Counts

Pasture larval counts were carried out by the technique of Lancaster (1970) modified by Sewell *et al.* (1983, unpublished). Two hundred grams of the mixed clippings were placed in approximately 10 litres of water in a bucket and a few drops of detergent added. This was left standing for 30 minutes before agitating. After removal of the washed herbage, the contents of the bucket were poured through a tier of sieves of mesh size 150µ-38µ-38µ. The contents of the lower two sieves were collected and centrifuged in two 100 ml tubes at 3000 rpm for five minutes. The supernatants were replaced with 100 ml of zinc sulphate (SG.1.1) in which the sediments were resuspended and centrifuged for three minutes at 1500 rpm. The supernatant was poured through a micropore plate (30µ hole), washed with water and the contents collected in two 15 ml conical centrifuge tubes. These were centrifuged for two minutes at 1500 rpm and the supernatant removed to leave only 0.1 ml of the deposit. Some 0.1 ml of Lugols iodine was added to each tube and left standing for at least one hour after which 0.1 ml of 0.3M sodium thiosulphate solution was added and mixed. After 2-3 minutes, the suspended contents were examined under the low power of the microscope and the infective larvae identified by their retention of the iodine stain in addition to their distinctive morphological features.

At Batibo, herbage samples were collected throughout the two years of the epidemiological study from the pastures jointly grazed by sheep and goats belonging to one of the co-operating farmers.

Necropsies

Necropsies and gastrointestinal worm counts were carried out by a modification of the techniques described by Ross (1963) and Ritchie *et al.* (1966). Each animal was laid on a flat surface and its abdomen opened by a vertical incision. The digestive tract and associated organs were removed and transferred in a covered bucket to the laboratory for detailed investigation.

The rumen, reticulum, abomasum, small intestine, caecum and large intestine were separately examined for helminth parasites. The washings from the abomasum and small intestine - and also from the large intestine when it was observed to contain more than 10 parasites - were made up to 10 litres with water and the number of nematodes present estimated from 10% and 2% aliquots. When the large intestine contained only a small number of worms, all were counted. The worms were counted under a stereo-microscope in a petri dish marked with parallel lines 2 cm apart. When doubt arose concerning the identity of a worm, this was confirmed under a compound microscope at a higher magnification.

Abomasal Digest

The abomasal mucosa was removed using the edge of a glass slide, suspended in 200 ml of 1% pepsin in 5% hydrochloric acid and incubated overnight at 37°C (Herlich, 1956; Hunter and MacKenzie, 1982). The larval stages released were counted under a stereomicroscope and identified according to Veglia (1915).

***Oestrus ovis* larval Counts**

Oestrus ovis larval infestation was investigated at post-mortem examination by opening up the head and thoroughly examining the nasal cavities, sinuses and brain, counting any larvae seen. The trachea and tracheoles were similarly opened and examined.

Haematological Techniques

Blood samples for haematology were collected from the jugular vein using vacutainer tubes (B-D Becton Dickinson, France) with trisodium citrate (at Mankon) or the disodium salt of ethylene diamine tetra-acetic acid (at the CTVM) as anticoagulant. The samples were taken early in the morning before the animals were turned out to graze or fed.

Packed cell volume

This was estimated by the microhaematocrit method (Dacie and Lewis, 1966).

Haemoglobin concentration

This was determined using the alkaline-haematin method (Dacie and Lewis, 1966) with a Zalimp photoelectric colorimeter (Zaklady Aparatury, Elektromedycznej I, Precyzyjnej, "Zalimp", Warszawa UI, Nowolipie 7a, Poland). The optical density in the colorimeter was read using a yellow-green filter at 545 nm.

Blood cell counts

Total red blood cell and leucocyte counts were estimated using an improved Neubauer haemacytometer and differential leucocyte counts were carried out on Giemsa stained blood films according to the techniques given by Schalm (1965).

MCV, MCH, MCHC

Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were calculated according to the formulae given by Schalm (1965).

Biochemical Techniques

Blood samples for serum were collected from the jugular vein of each animal into plain vacutainer tubes and allowed to clot at ambient temperature for one or two hours or in an incubator at 37°C for one hour. They were then left overnight in a refrigerator at 4°C. The clotted samples were centrifuged at 3000 rpm for 30 minutes. Each serum sample was transferred into a labelled sterile injection bottle (at Mankon) or bijou bottle (at the CTVM), labelled and stored at -20°C until required.

Total serum protein

Total serum proteins were determined by the Biuret technique using a Zalimp photoelectric colorimeter according to Dacie and Lewis (1966) modified from Henry *et al.* (1957). The optical density was read using the yellow-green filter at 545 nm. The increased absorption, as compared with that for a distilled water blank, was converted into g/dl protein by reference to a standard curve for the colorimeter and the cuvettes in use, which had been previously prepared using dilutions of seronorm (Nyegaard & Co., A/s Oslo, Norway).

Serum albumin

Serum albumin values were obtained by the immediate bromocresol green procedure employing species specific standards (Keay and Doxey, 1983). The absorption was read at 610 nm in a Zalimp photoelectric colorimeter against a blank of working dye solution. The readings so obtained were applied to the appropriate calibration curve, drawn using a range of working ovine and caprine albumin standards, to obtain the serum albumin concentration in g/dl.

Serum globulin

Serum globulin values were calculated by subtracting the albumin values of the samples from the appropriate total protein values.

Serum pepsinogen

Serum pepsinogen levels were determined by the method of Edwards *et al.* (1960) adapted by Jennings *et al.* (1966).

Statistical Analyses

Statistical analyses were carried out by the methods described by Steel and Torrie (1960) and Scott (personal communication). Differences in weight gains between treatments were determined by analysis of variance and Student's t-test. Differences in survival rates were determined by chi-square or Fisher's exact test. The differences in egg counts between different classes of animals or animals under different treatments were investigated using the Mann-Whitney U test for two groups or the Kruskal-Wallis test for three or more groups. Significant changes in egg counts for the same group were assessed using Wilcoxon's signed rank test. Comparisons of worm counts from different treatment groups were carried out by the Mann-Whitney U test or the Kruskal-Wallis test. Size differences between worms from different treatment groups were determined by analysis of variance and Student's t-test. Differences in haematological and biochemical values between treatments were also investigated by Student's t test and analysis of variance (packed cell volume and mean corpuscular haemoglobin concentration being first subjected to arcsine transformation). Differences between treatment means were tested using the least significant difference (lsd) test, any two means differing by more than the calculated lsd value being considered to be significantly different at the probability level indicated. Significant changes in any one data type within the same group of animals were assessed using a paired t test. Correlations between faecal egg counts and worm counts, packed cell volumes, haemoglobin concentrations or serum pepsinogens were determined by a non-parametric method employing the Spearman rank-correlation coefficient. Regression slopes for changes in haematological and biochemical values during experimental infections were compared with the controls using the t-test.

HAEMATOLOGICAL AND BIOCHEMICAL PARAMETERS

IN NORMAL SHEEP AND GOATS

INTRODUCTION

Haematological and biochemical values of normal sheep and goats are needed to provide a standard that can be used to assess the health status of the animals in this study and to assess whether they differ from published data under farm conditions for animals in other areas. It was not possible to get truly normal haematological and biochemical values of the animals in this study kept under farm or village conditions because these were confounded by either malnutrition in the dry season or helminthiasis in the rainy season. The nearest approach to obtaining such normal values was to use the samples from animals that had been kept under helminth-free conditions for experimental studies. Since these animals were inevitably only lambs and kids, the age effect on the normal values could not be determined. However, the consistently significant differences in haematological and biochemical values between sheep and goats could be assessed.

A comparison was also carried out between electrophoresis and the bromocresol green method of albumin determination to assess the reliability of the latter technique in determining the albumin concentrations.

EXPERIMENTAL DESIGN

1. Determination of haematological and serum biochemical parameters in normal sheep and goats: Twenty-eight helminth-free Grassland Dwarf lambs and 27 kids (19 Grassland Dwarfs and 8 Red Sokotos) of ages ranging between three and six months were used. Blood samples were collected from these animals prior to their being used in experimental infection studies. The parameters measured were for:

(a) Haematology: the packed cell volume, haemoglobin concentration, red and white blood cell counts, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration.

(b) Serum biochemistry: the total protein concentration, albumin concentration, globulin concentration, albumin/globulin ratio and pepsinogen concentration.

2. Comparison between electrophoresis and the bromocresol green method of albumin determination: When it was noticed that there was a

marked difference in albumin/globulin ratio as between sheep and goats when using the bromocresol green method, it was decided to compare this technique with a standard electrophoretic technique with serum samples from locally available animals. Samples were analysed from 34 sheep (26 indigenous and 8 exotic) and 60 goats (34 indigenous and 26 exotic) by both methods. The sera had been stored at -20°C for up to 11 months between the albumin estimation by the two techniques.

The electrophoresis was carried out in a Shandon electrophoresis tank on cellulose acetate paper 77 x 150 mm with 0.05-0.07M barbital buffer using the method described by Kohn (1970). Current was maintained at 7 amps and each run lasted 45 minutes. The stained strips were scanned on a Beckman densitometer (Beckman Instruments, Wycombe, Bucks.). The relative (percent) serum albumin values determined by electrophoresis were converted to absolute (g/dl) values by calculation from each total serum protein concentration as estimated by the biuret method.

RESULTS

The mean haematological values in normal sheep and goats are given in Table 17. The values were not significantly different as between the two breeds of goats except for the slightly higher red and white blood cell counts in the Red Sokoto goats. On the other hand, sheep had consistently and significantly higher values for packed cell volume, haemoglobin concentration, mean corpuscular volume and mean corpuscular haemogloblin and lower values for the red and white blood cell counts than the goats. The packed cell volume values were, however, not significantly different in sheep and Red Sokoto goats. The mean corpuscular haemoglobin concentration values were generally similar in both species.

The mean serum biochemical values are shown in Table 18. The Grassland Dwarf goats tended to have higher total protein and globulin concentrations and lower albumin values than sheep. The total protein and albumin values of the Red Sokoto goats were intermediate between the Grassland Dwarf goats and the sheep and not significantly different from either. Both breeds of goats had significantly lower albumin/globulin ratios than sheep. The serum pepsinogen levels were low and generally similar in sheep and goats.

The data for the albumin values determined by bromocresol green method and electrophoresis are shown in Table 19. The goat albumin values determined by the bromocresol green method were consistently lower than

Table 17 Mean haematological values (± standard deviation) in normal lambs and kids

Breed	No of animals examined	PCV (%)	Hb conc. (g%)	RBC (x10 6) per cmm blood	MCV (fl)	MCH (pg)	MCHC (%)	WBC (x10 3) per cmm blood
Grassland Dwarf sheep	28	30.0±4.0	10.6±1.6	9.9±1.5	30.4±2.3	10.8±1.8	35.4±4.5	10.4±2.8
Grassland Dwarf goats	19	26.5±2.9	9.1±1.6	13.2±1.3	20.2±2.9	6.9±1.4	34.5±5.2	15.8±4.4
Red Sokoto goats	8	28.1±2.9	8.8±1.2	14.5±1.6	19.5±2.4	6.1±0.9	31.4±2.6	20.5±6.1
Level of significance (P <) of difference between:-								
GD sheep v. GD goats		0.01	0.01	0.001	0.001	0.001	ns	0.001
GD sheep v. Red Sokoto goats		ns	0.01	0.001	0.001	0.001	0.05	0.001
GD goats v. Red Sokoto goats		ns	ns	0.05	ns	ns	ns	0.05

Table 18 Mean total and differential serum protein and pepsinogen concentrations (± standard deviations) in normal lambs and kids

Breed	No. of animals examined	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G ratio	Serum pepsinogen (x10 3) mU Tyrosine
Grassland Dwarf sheep	28	7.9±0.8	4.2±0.6	3.7±1.0	1.2±0.4	0.34±0.28
Grassland Dwarf goats	19	8.6±0.8	3.3±0.3	5.3±0.9	0.7±0.2	0.22±0.20
Red Sokoto goats	8	8.3±0.8	3.8±0.5	4.6±0.9	0.9±0.3	0.52±0.29
Level of significance (P <) of difference between:-						
GD sheep v. GD goats		0.01	0.001	0.001	0.001	ns
GD sheep v. Red Sokoto goats		ns	ns	0.05	0.05	ns
GD goats v. Red Sokoto goats		ns	0.05	ns	0.05	0.01

Table 19 Serum albumin values from sheep and goats by the immediate bromocresol green reaction and by electrophoresis

Source of sera	No. of animals	Albumin concentration (g/dl) BCG	Electrophoresis	Level of significance of difference between albumin values obtained by BCG and electrophoresis t value	P <
Ovine	34	4.1 ± 0.6	3.8±0.4	2.346	0.05
Caprine	60	3.2±0.5	3.6±0.5	7.118	0.001
Exotic sheep	8	4.5±0.3	4.2±0.3	1.821	ns
Exotic goats	26	3.1±0.5	3.7±0.5	7.820	0.001
Indigenous sheep	26	4.0±0.6	3.6±0.3	3.498	0.01
Indigenous goats	34	3.3±0.6	3.6±0.5	2.017	ns

those determined by electrophoresis, while the sheep albumin values determined by the bromocresol green method were consistently higher than those determined by electrophoresis.

DISCUSSION

The higher PCV and MCV and the lower RBC and WBC in sheep than in goats, and similar values of MCHC in both species are in conformity with the results of Oduye (1976) for clinically healthy Nigerian sheep and goats. Anosa and Isoun (1976) similarly observed higher PCV values in dwarf sheep compared to dwarf goats at Jos Plateau, Nigeria. Oduye (1976) observed that the erythrocytic values in goats were not significantly affected by age whereas in sheep there was a decrease in RBC and an increase in MCV values with advancing age. Studies by Somvanshi *et al.* (1987) on Indian pashmina goats indicated that in newborn kids the Hb, MCHC and PCV values were higher and total leucocyte lower than in other age groups.

The primary haematological values for sheep in these studies in Cameroon and Nigeria are much lower than those reported by Holman (1944) (RBC = 11.5 x 10^6, PCV = 36.5%, HB concentration = 12.4 g%), Hackett *et al.* (1957) (RBC = 10.89 x 10^6, PCV = 35%, Hb concentration = 10.78 g%) and Fernandez et al. *(1984) (RBC = 11.5 x* 10^6, PCV = 35%, Hb concentration = 11.8 g%) for sheep. Since the animals used in the present study were helminth-free, the low erythrocytic values in sheep may be attributed to low intake of iron (Oduye, 1976). On the other hand, the differences observed between Grassland Dwarf and Red Sokoto goats suggest that there are also breed differences in the haematological and biochemical values, some of which may be significant.

There were also consistently clear differences in the serum biochemical values between sheep and goats. Saad *et al.* (1984) did not observe any significant species differences in the values of these parameters in uninfected Sudanese Dorset sheep and Nubian goats. Irfan (1967) recorded slightly higher total protein and albumin values in goats than in sheep but his observations were based on a very small sample. Turner and Wilson (1962) noted in Shropshire lambs that the A/G ratio and total serum protein values rose as the animals matured when significant parasitic infections were absent. The serum pepsinogen levels observed in normal sheep and goats in this study are similar to 0.429±0.176 mIU/ml plasma recorded by Suten and Kedar (1983) from lambs with negative faecal tests.

The albumin values determined by electrophoresis and the BCG method

were positively correlated except in the case of the indigenous sheep. However, these correlations were remarkably low, considering that the two techniques are supposed to be measuring the same parameter. Keay and Doxey (1983) obtained comparable values by the two methods for sheep albumin but Bain (1986) cautioned that differences may occur in the calculated concentrations dependent on the method employed although he did find a significant correlation between the two procedures ($r = 0.886$, $p < 0.001$). However it is clear that the BCG method in the present study tends to over-estimate sheep albumin and under-estimate goat albumin although it appears to be a poor predictor of the "true", that is electrophoretically determined level.

Reasons for the poor correlation between the two techniques are not readily apparent, although the small range of values in such normal sera may have contributed to this. Another factor may have been the long period during which some of the sera had been stored between the BCG and the electrophoretic albumin determinations. It is noteworthy that in the case of 16 Red Sokoto goats, where the two techniques were performed on the same day, the correlation between the two methods was high (0.91).

The results obtained by electrophoresis indicate that although sheep probably have higher albumin values than goats, the differences were smaller than shown by the bromocresol green method and were generally not significant. Nevertheless, because the necessary equipment was not available for the earlier part of the study and for reasons of consistency and facility, the BCG method was used in all the other epidemiological and experimental studies.

EPIDEMIOLOGICAL STUDY 1984-1985

INTRODUCTION

At the onset of the epidemiological study on parasitic gastroenteritis at the Animal Research Station in Mankon, it was ascertained that full doses of 7.5 mg/kg body weight of fenbendazole had been used on a regular monthly basis on all the small ruminants on the station for several years. This regime was therefore used as the control in the first year's study designed to investigate the effect of reducing the frequency of anthelmintic treatment on the survival and production of these animals. The periods chosen for prophylactic treatment in the reduced anthelmintic regime closely corresponded to those proposed by Fabiyi (1973) for control of helminths in the northern savanna area of Nigeria.

EXPERIMENTAL DESIGN

There were three treatment groups for both sheep and goats. These were:-

Standard: The method of management previously used at Mankon in which the animals were kept on improved grazing with some supplementary feeding (Table 16) and monthly anthelmintic treatment with fenbendazole (Panacur, Hoechst) at 7.5 mg/kg body weight.

Reduced anthelmintic: A regime which was similar to the standard regime except that fenbendazole at 7.5 mg/kg body weight was given five times in the year, in the first weeks of November, December, March, July and September.

Traditional: The management methods used in the village whereby animals were kept in small flocks with little or no supplementary food and no anthelmintic treatment. They were usually tethered between March and August or September (cropping season) and left on free range between September and February (non-cropping season).

The animals in the standard and reduced anthelmintic groups were kept at the research station in Mankon while the animals in the traditionally managed group were with local farmers at Batibo.

The distribution of the ages and sexes of the animals is shown in Table 20 as is the number of animals with each farmer in Batibo. The two groups of 21 sheep each at Mankon were set-stocked on approximately half-hectare paddocks while the two groups of 20 goats were each kept on two one-quarter hectare paddocks, each paddock being grazed in alternative months as the herbage was eaten off. Problems connected with the

Table 20 Age and sex distribution of experimental sheep and goats kept under three different management regimes in North West Province of Cameroon

Site	Management group	Grassland Dwarf sheep			Grassland Dwarf goats		
		Adult males	Adult females	Lambs	Adult males	Adult females	Kids
Mankon	Standard	5	11	5	1	9	10
	Reduced anthelmintic	5	11	5	2	8	10
Batibo Farmer	Traditional	1	9	2	1	11	6
	A	0	0	0	1	5	1
	B	0	3	1	0	2	1
	C	0	4	0	0	2	3
	D	1	2	1	0	2	1

availability of grazing on the pastures necessitated the choice of this grazing management pattern for the Mankon animals. The sample size of 21 and 20 sheep and goats respectively per management group was chosen taking cognizance of the probable optimum stocking rate for the paddocks available. The animals used were of mixed ages and sex because it was not possible to obtain enough animals of the same age and/or sex.

The traditionally managed animals at Batibo belonged to four farmers (Table 20).

Even though most families in the North West Province of Cameroon keep small ruminants, the average number per owner is quite small. Thus, it needed four farmers' animals in Batibo to obtain a flock size that was adequate for this study. One of the owners of the animals with which the study commenced withdrew his cooperation in January 1985 and was replaced by another owner. The details for the first owner are not given in Table 20 and most of the data for this group refers to the period after this time.

Tracer animals (2 lambs and 2 kids on each occasion) were placed on the pastures used by two of the farmers (Farmers C and D) who kept both sheep and goats, at the beginning of each month between December 1984 and October 1985 as a means of assessing the infectivity of these pastures. They grazed for 28 days after which they were withdrawn and kept indoors for two weeks before being necropsied for parasitological investigation. Between March and September when these farmers tethered their animals, the tracer animals were similarly tethered and managed in the same way as the farmers' animals.

The parameters measured included:-

(a) Liveweights determined in the middle and at the end of each month for the animals at Mankon and once a month for the traditionally managed animals.

(b) Faecal egg counts were also determined twice a month for the animals at Mankon and once a month for the traditionally managed animals.

(c) Larval cultures and differentiation using pooled faecal samples collected from the different classes of animals (lambs, kids, ewes, does, rams and bucks) were carried out once a month for each treatment group at Mankon.

(d) Pasture larval counts performed once a month.

(e) Worm counts were carried out on the tracer animals and on those animals from the experiment which died during the study.

(f) Haematology (packed cell volume, haemoglobin concentration, red and white blood cell counts, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration) determined once a month except in the traditionally managed animals where this was carried out only in February, May and August.

(g) Serum biochemistry (total protein, albumin, globulin and pepsinogen) at the same time as the haematology. The study lasted from November 1984 to October 1985.

RESULTS

Meteorological Data

The temperature and rainfall data are summarised in Figure 3. Between December and mid-March, rainfall was either very scanty or nil. This period is referred to as the dry season. At this time the ground becomes hard and most of the grass withers, the only fresh vegetation being found on shrubs or trees in the valleys and along the banks of streams and rivers. The wet season extends from mid-March to mid-November with a peak in August. Monthly mean minimum temperatures were above 15°C except between November and February.

Table 21 Mean initial liveweight and mean weight gains in sheep and goats in the N.W. Province of Cameroon 1984-1985

Type of animals	Sex/Age	Type of management	Number of animals	Initial liveweight (kg)	Liveweight gain (kg) January-October	Liveweight gain (kg) November-October
Sheep	Lambs	S	4	7.7	10.4	15.4
		R	5	7.5	11.9	15.6
		T	2	15.0*	-	1.6
	Adult females	S	9	21.3	2.8	6.4
		R	9	21.1	2.2	5.8
		T	1	21.5*	-	-5.0
	Adult males	S	3	22.1	11.6	15.1
		R	5	22.4		15.6
		T	1	19.0	-	-0.7
Goats	Kids	S	8	10.9	2.7	3.1
		R	8	11.4	1.1	1.5
		T	5	8.9	2.8	6.1
	Adult females	S	9	20.3	0.2	-0.1
		R	7	21.7	0.5	-2.0
		T	7	20.9	2.1	4.1
	Adult males	S	1	18.0	3.2	4.0
		R	2	17.0	3.1	2.1
		T	1	16.2	1.7	1.5

*Mean initial weight in January; Other initial weights in November.

S = Standard regime; R = Reduced anthelmintic regime; T = Traditional management

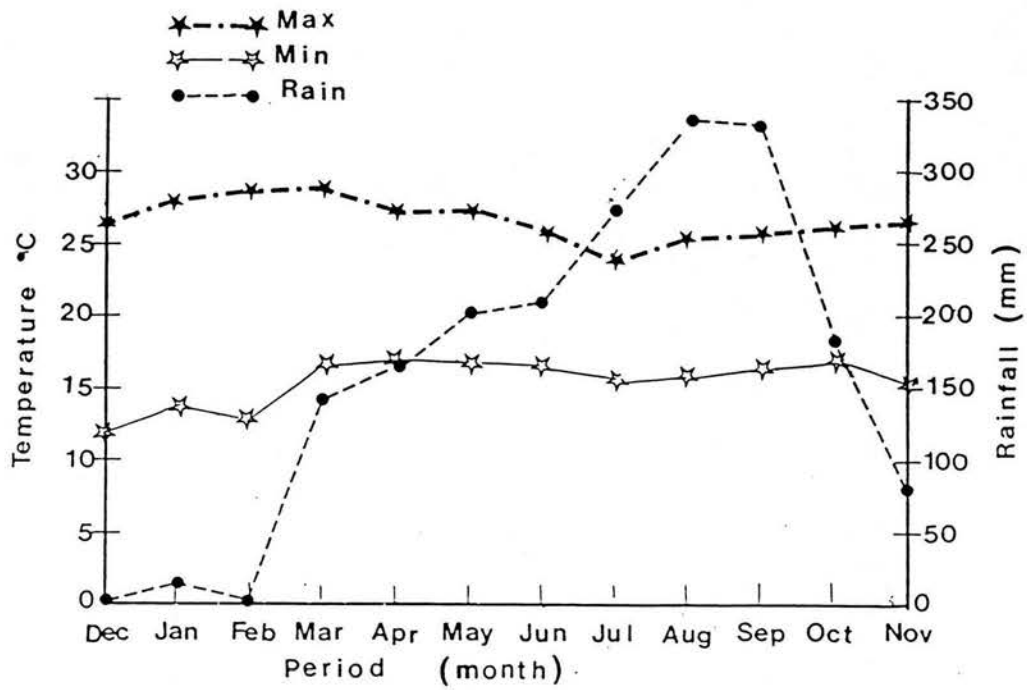


Figure 3 Meteorological data for Mankon 1984-85
Mean monthly maximum temperature
Mean monthly minimum temperature
Total monthly rainfall

Productivity

The liveweight changes during 1984-85 are shown in Table 21 and Appendix 3. At Mankon the reduced anthelmintic regime gave similar results in terms of liveweight gain and survival (Table 22) to the standard regime. This applied to both sheep and goats and to young stock and adults alike. The goats at Mankon grew less well than the sheep and although they performed slightly better on the standard regime than on the reduced regime, this difference was not significant. Sheep kept by traditional local methods survived significantly ($P < 0.001$) less well than goats (Table 22). They also grew ($P < 0.01$) more slowly and survived less well ($P < 0.01$) than sheep kept under either management system at Mankon (Tables 21 and 22). In contrast goats grew better ($P < 0.005$) when kept by the traditional local methods than they did at Mankon although they were in general lighter and grew more slowly than sheep.

Table 22 Mortality in sheep and goats under three management systems

Management system	Animals that died/animals in group (percentage mortality)	
	Sheep	Goats
Standard Mankon management	4/20 (20%)	2/20 (10%)
Reduced anthelmintic regime	2/21 (10%)	3/20 (15%)
Traditional village management	9/13 (69%)	1/18 (6%)

Data on reproductive performance of sheep and goats under the three management systems studied are shown in Table 23. Goats were more prolific and showed a greater twinning rate ($P < 0.005$) than sheep. They produced more young per year when they were kept by the traditional local methods than they did at Mankon. The kiddings were concentrated in November, February and June while most of the lambings occurred in March and September. The standard regime gave similar results to the reduced regime on reproductive performance.

Faecal egg counts

The strongylid egg counts are presented in Figures 4-7 and Appendix 3. The counts made 15 days after treatment were normally similar to those prior to treatment, except when the latter were relatively high. This was illustrated

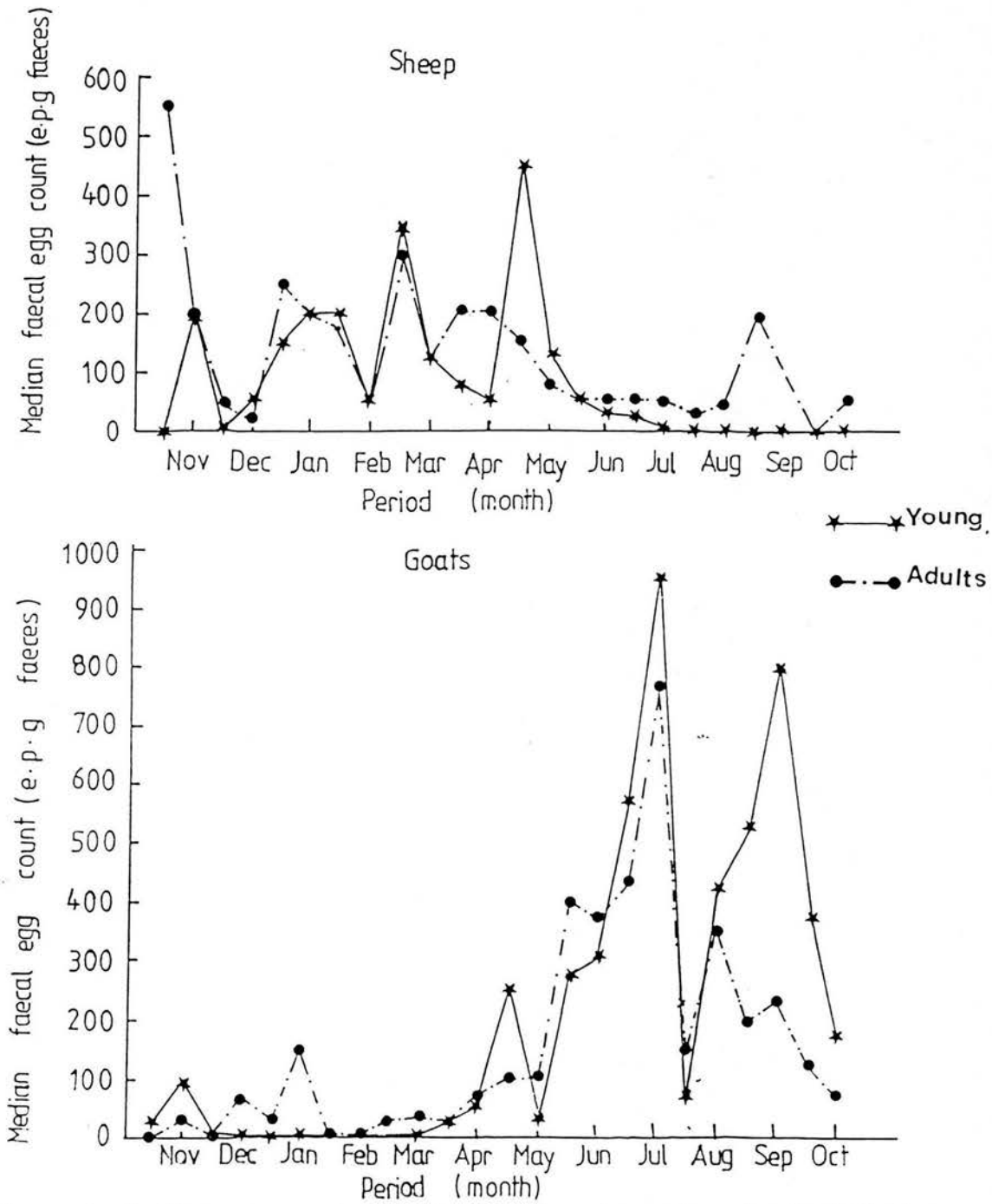


Figure 4 Median egg counts of sheep and goats under standard Mankon management (Nov. 1984-Oct. 1985).

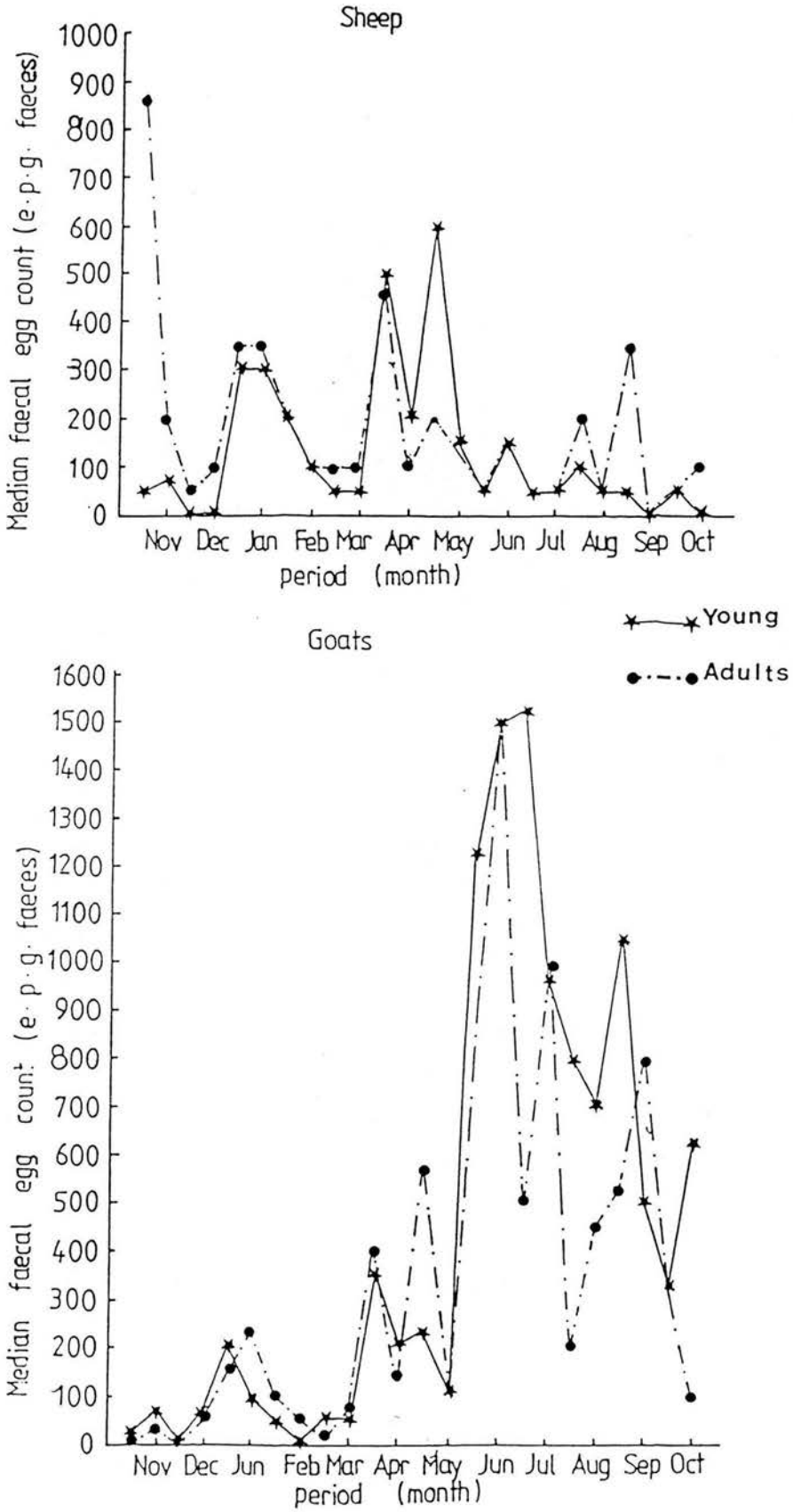


Figure 5 Median egg counts of sheep and goats under reduced anthelmintic regime (Nov. 1984-Oct. 1985).

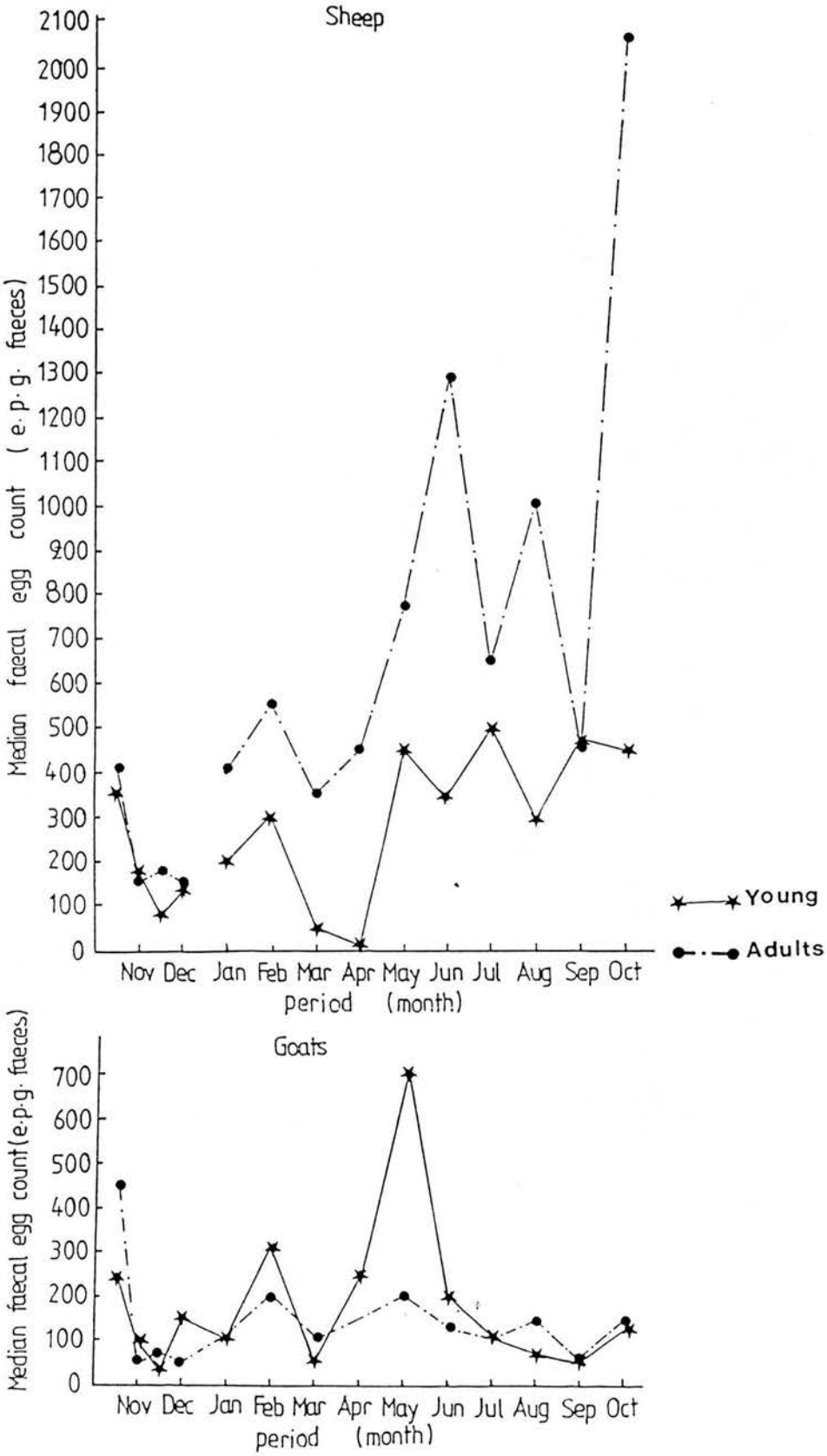


Figure 6 Median egg counts of sheep and goats under traditional village management (Nov. 1984-Oct. 1985).

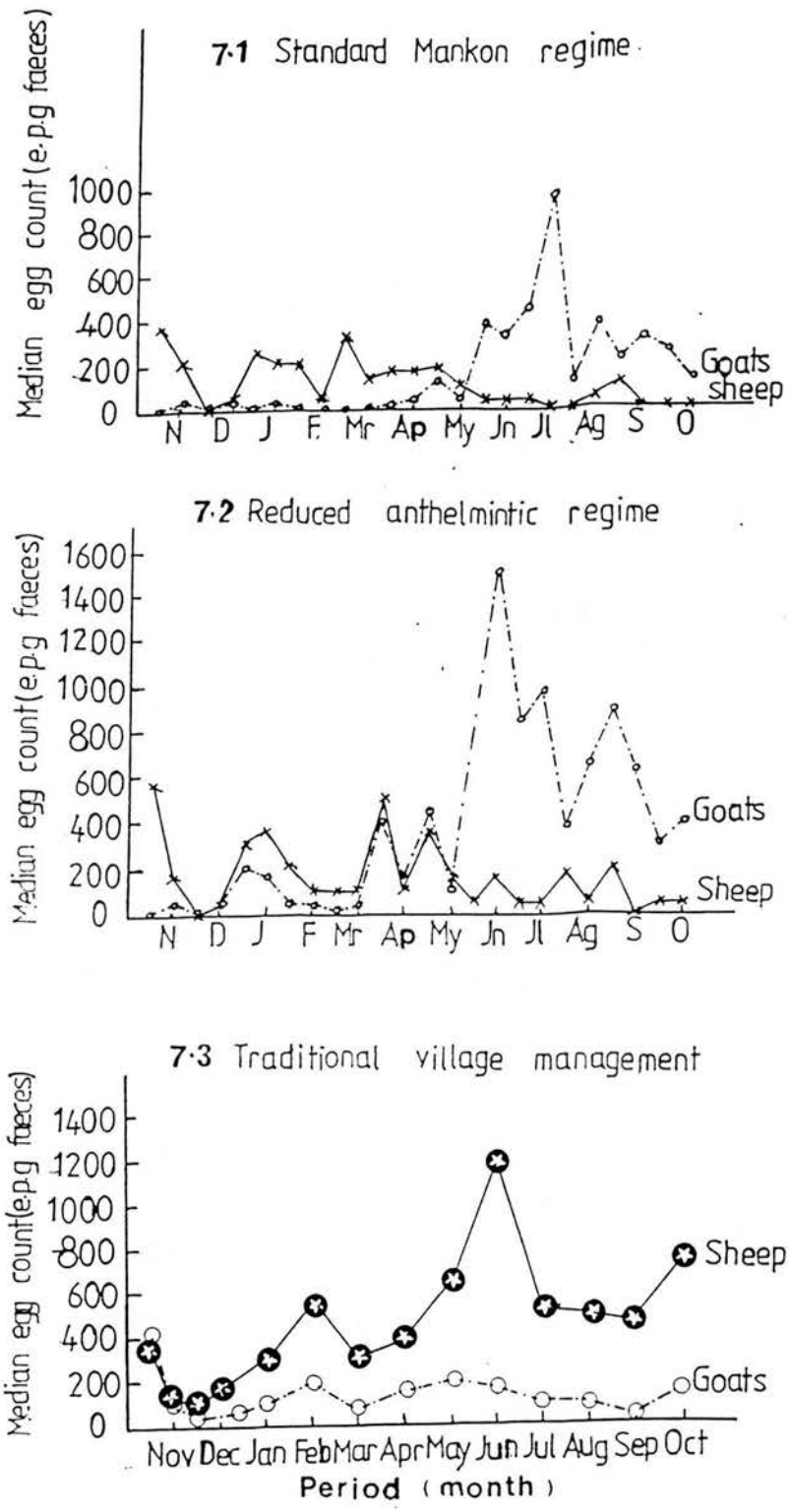


Figure 7 Median egg counts of sheep and goats under different management systems (Nov. 1984-Oct. 1985).

by the significant reduction of faecal egg counts in goats on the standard regime after the treatment at the end of July ($P < 0.01$) (Figure 4).

Table 23 Reproductive performance of sheep and goats under three management systems in the North West Province of Cameroon

Parameters measured	Sheep			Goats		
	Standard	Reduced	Traditional	Standard	Reduced	Traditional
No. of females	11	11	9	10	9	11
No. pregnant	9	9	5	9	7	10
No. of parturitions	11	11	5	9	10	16
No of young born	12	12	5	12	14	21
Fertility (%)	82	82	56	90	78	91
Prolificacy (%)	109	109	100	133	140	131
Lambing/kidding rate (%)	109	109	56	120	156	191
Reproductive rate (young/female/year)	1.3	1.3	1.0	1.3	2.0	2.1
% single births	91	91	100	67	60	69
% twin births	9	9	0	33	40	31
Average birth weight (kgs)		2.5			1.7	

The egg counts from both sheep and goats fell sharply at the start of the dry season (November to December) and remained low until April regardless of the system of management or frequency of anthelmintic treatment. Throughout this period the counts were generally significantly lower in the goats than in sheep on standard anthelmintic regime ($P < 0.01$) and traditional management ($P < 0.05$).

At Mankon the counts from the sheep on the reduced regime rose briefly at the start of the wet season, but fell thereafter; those in the sheep on the standard regime remained low throughout. The faecal egg counts from goats in both groups rose rapidly, reaching maximum levels in June for the reduced anthelmintic regime and July for those on the standard regime. At their peak in July the counts from the goats were more than four times those from the sheep. The egg counts from the traditionally managed goats were consistently low (< 200 eggs). In the village sheep the egg output rose in the latter part of the dry season to a peak in June, with a further peak in October.

The pattern of strongylid egg output in lambing and kidding females at the research station showed evidence of a peri-parturient rise despite the seasonal effect on all animals (Figure 8). The egg count started to rise rapidly

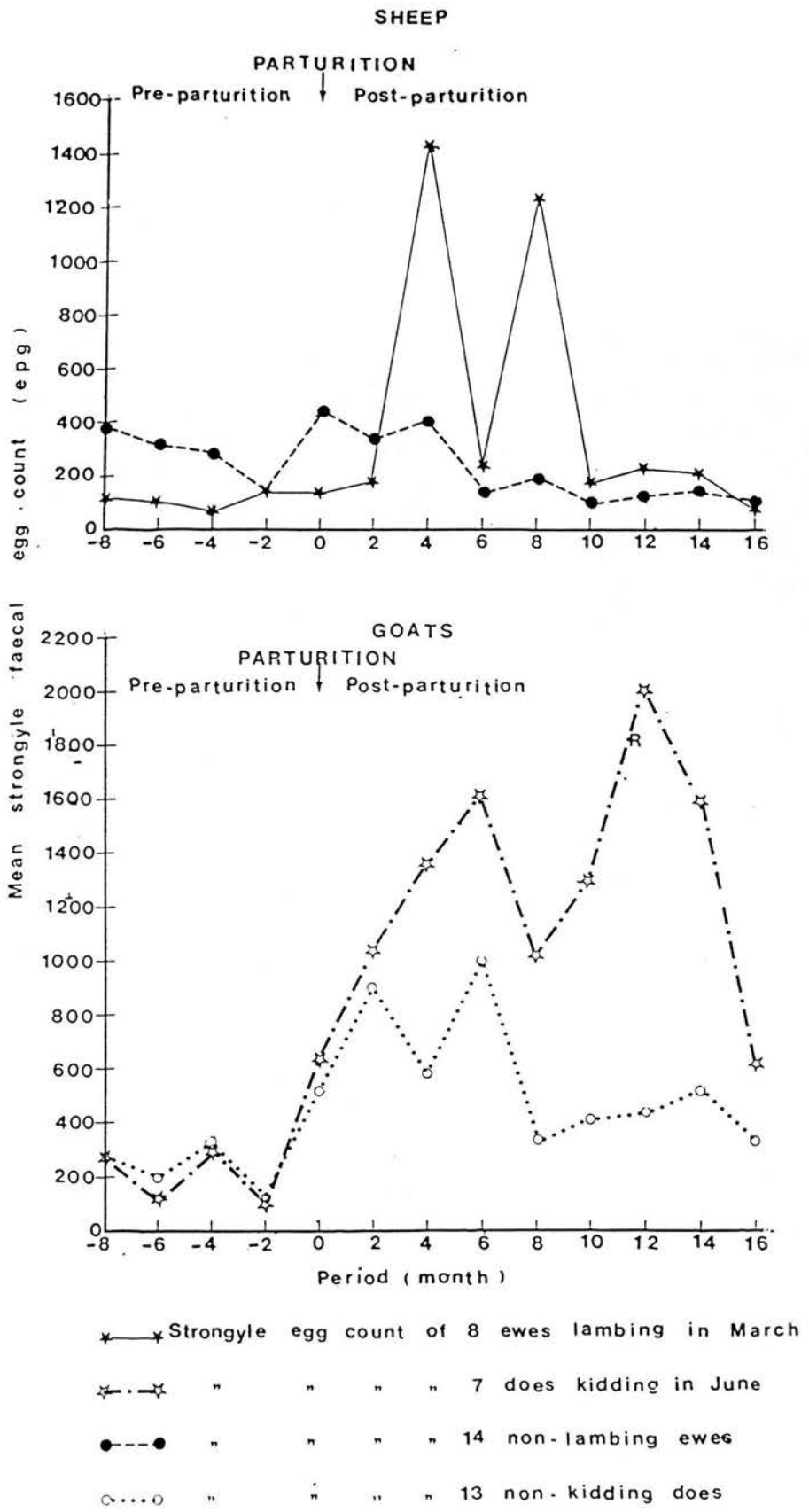


Figure 8 Peri-parturient rise in strongyle egg counts of sheep and goats in the North West Province of Cameroon.

from about two weeks after parturition and remained elevated for 2-3 months. Throughout this period the counts were consistently higher than in animals that did not lamb or kid during the same period. A similar trend in egg counts was observed in the traditionally managed sheep but the traditionally managed goats did not show any significant change in faecal egg count following parturition.

The egg counts from the lambs on standard regime and traditional management were significantly lower ($P < 0.05$) than those from adults during the rainy season while counts from ewes and rams were similar. On the other hand, the egg counts from kids, does and bucks were similar.

Larval cultures and differentiation

The results from the larval cultures are summarised in Table 24. A significantly ($P < 0.05$) higher proportion of the eggs from sheep were *Haemonchus* than in goats. *Oesophagostomum* larvae were only occasionally present in the animals at Mankon and then in a low proportion.

Pasture contamination - herbage larval counts

The pattern of pasture larval contamination is shown in Figure 9. In general, the contamination remained relatively low on both the sheep and goat pastures throughout the dry season, especially between January and April. Following the onset of the rains the contamination of the herbage rapidly rose to a peak. The lowest recoveries of infective larvae during the rainy season were made in August and September, the months with the heaviest rains (340 mm and 330 mm respectively). Pasture larval contamination again rose temporarily at the end of the rains. Traditionally managed pastures were the least heavily contaminated but remained infective throughout the year.

Pasture infectivity - worm counts from tracer animals

Data on the infectivity of the traditionally managed pastures assessed by use of tracer animals is summarised in Figures 10 and 11. It is clear that all the pastures remained infective throughout the year. The total worm burdens in tracer kids (Figure 10) remained low (< 500) between December and April but then increased to a peak in August at a time when the burden in the tracer lambs was low. In general the worm burden in tracer lambs was heavier than in tracer kids but the difference was not significant.

The highest worm counts for most of the worm species were obtained during the wet season but at different times during this period (Figure 11). The predominant nematodes throughout the year were *Haemonchus contortus*, *Trichostrongylus axei* and *T. colubriformis*. No inhibited larval forms of *H.*

Table 24 Larval differentiation from larval cultures (1984–1985)

Animal species	Class of animal	% Prevalence of infective larvae under Standard Mankon Management			% Prevalence of infective larvae under Reduced anthelmintic regime			% Prevalence of (Mean for both groups)		
		Haem.	Tricho.	Oesoph.	Haem.	Tricho.	Oesoph.	Haem.	Tricho.	Oesoph.
Sheep	Lambs	68.18	31.82	–	78.64	21.36	–	73.41	26.59	–
	Ewes	46.45	53.55	–	67.18	32.82	–	56.82	43.18	–
	Rams	68.18	31.82	–	60.45	38.82	0.73	64.32	35.32	0.36
	Mean	60.94	39.06	–	68.76	31.00	0.24	64.84	35.03	0.13
Goats	Kids	28.18	71.82	–	57.91	41.45	0.64	43.04	56.64	0.32
	Does	62.30	37.70	–	41.5	56.60	1.90	51.90	47.15	0.95
	Bucks	36.89	63.11	–	54.40	45.20	0.40	45.65	54.15	0.20
	Mean	42.46	57.54	–	51.27	47.75	0.98	46.86	52.65	0.49

Haem. = Haemonchus contortus; Tricho. = Trichostrongylus spp.;

Oesoph. = Oesophagostomum columbianum

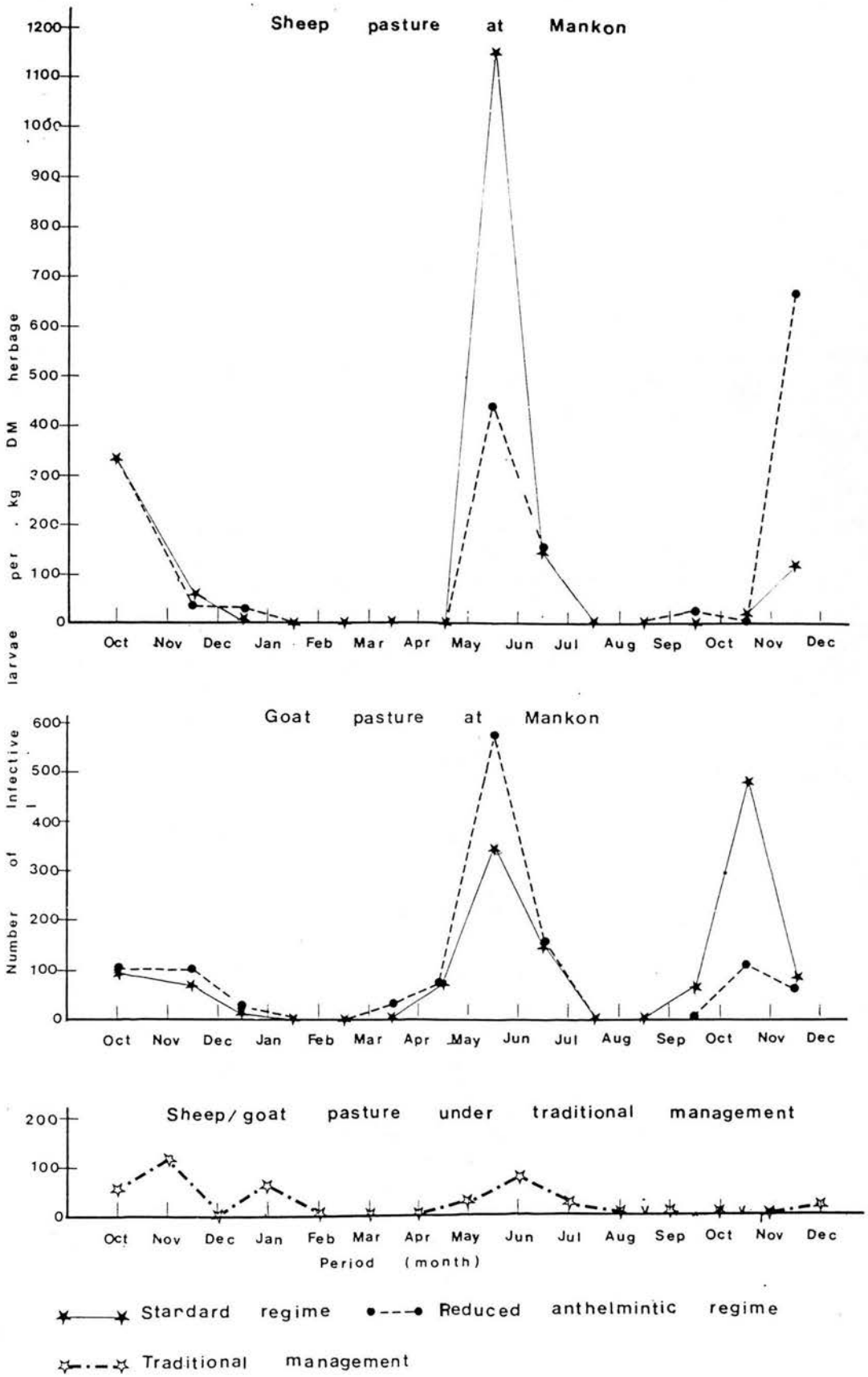


Figure 9 Pasture larval contamination under three management systems in the North West Province of Cameroon.

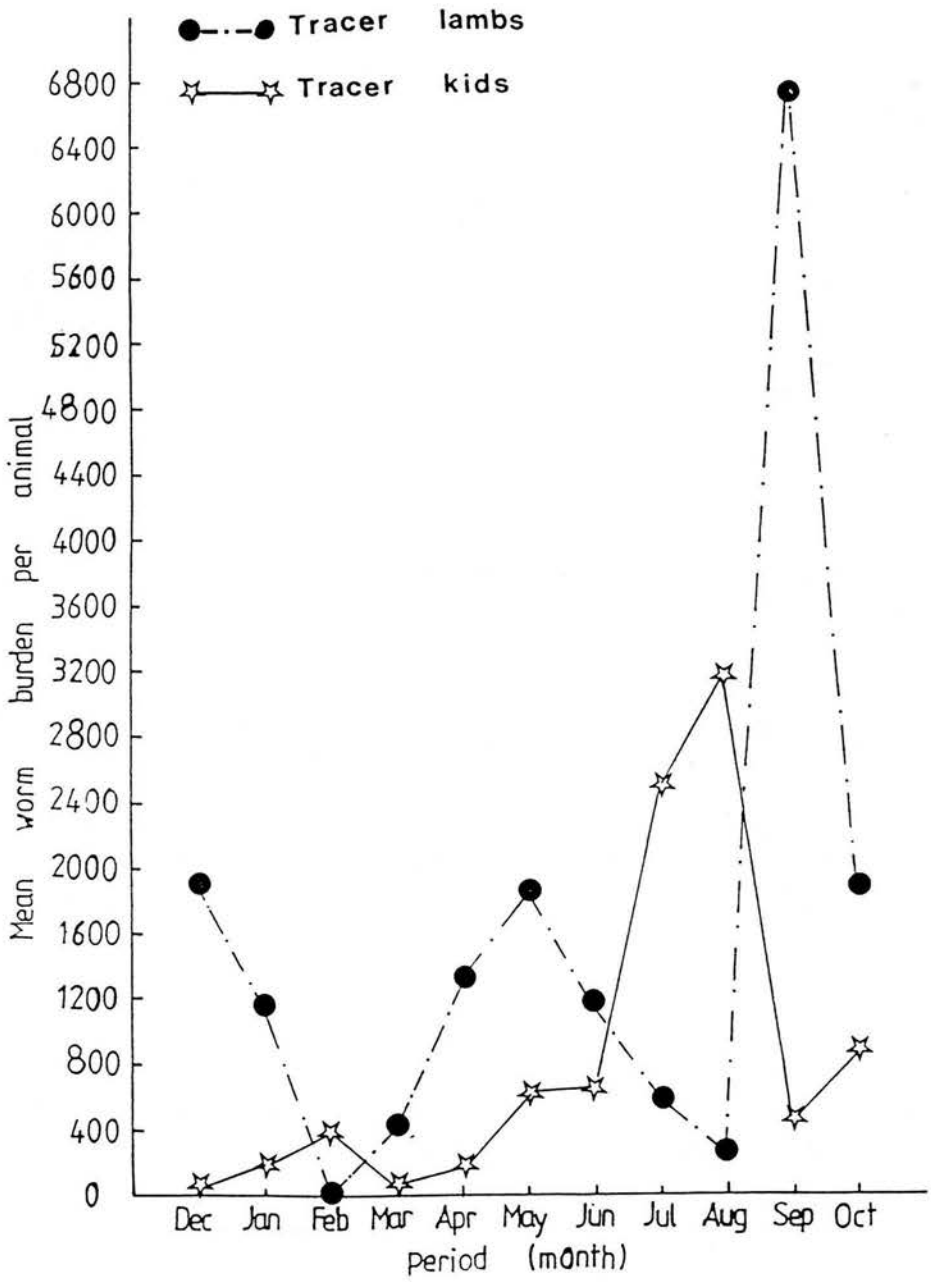


Figure 10 Total worm counts from tracer lambs and kids (seasonal pattern) 1984-85.

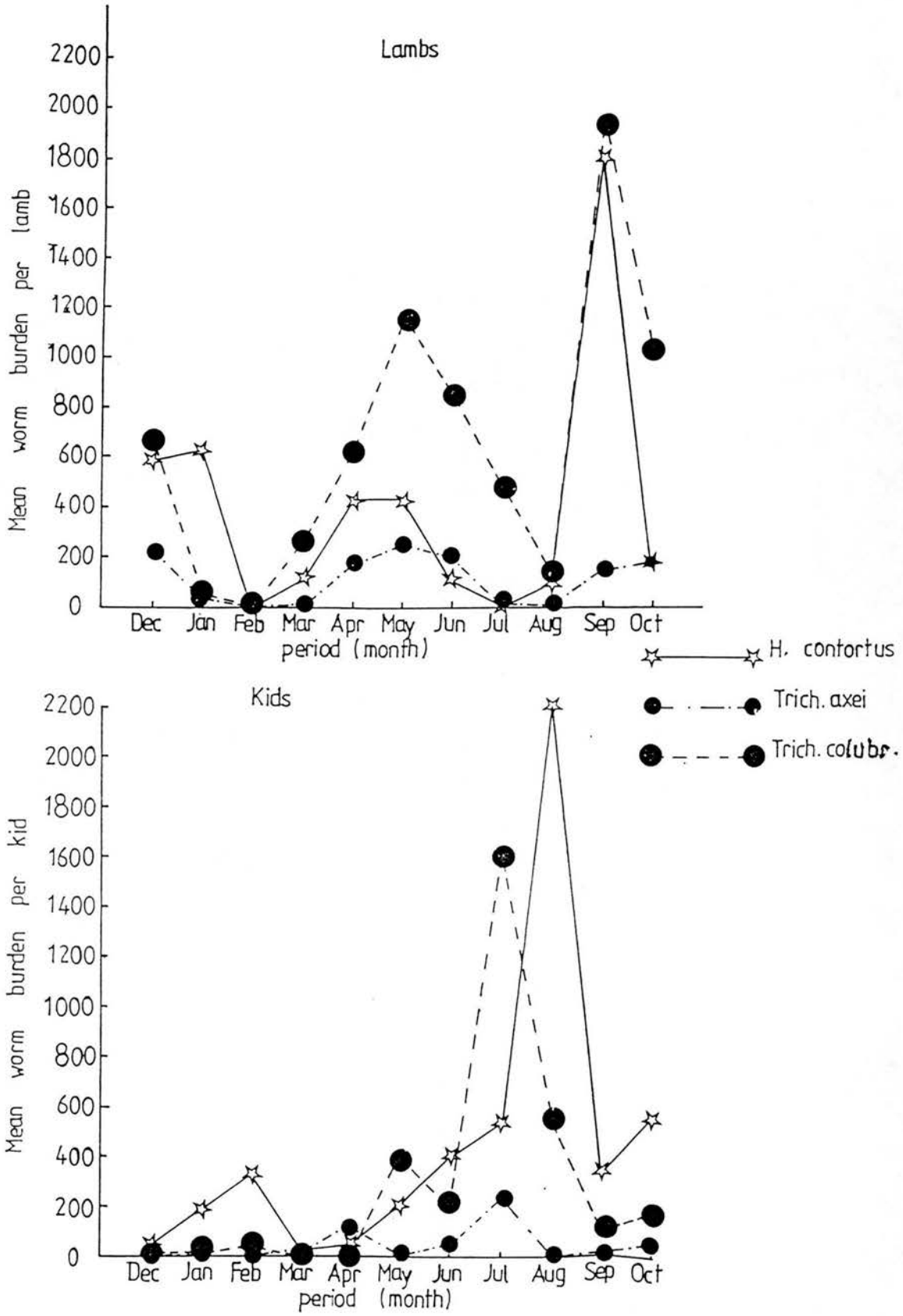


Figure 11 Pattern of worm infections in tracer animals, 1984-85.

contortus or *T. axei* were observed in abomasal digests.

Oesophagostomum columbianum was absent in the dry months between January and March, with low peak counts (< 500) in kids in August and in lambs in September. *Bunostomum trigonocephalum* was virtually absent during the dry season but was recovered in small numbers (< 500) from lambs throughout the wet season. *Strongyloides papillosus* was observed from July with peak counts in September. *Trichuris ovis* was only occasionally found, the largest number from one animal being 34 in August. The tapeworm *Moniezia expansa* and metacestodes (mainly *Cysticercus tenuicollis*) were present in virtually all months of the year, with highest numbers during the rainy months.

Necropsy of experimental animals

Post-mortem examination of animals that died during the experiment revealed that most of them contained large numbers of nematodes (Table 25). Most of the deaths, especially those of the sheep, occurred amongst animals under traditional management.

There were higher worm counts in animals that died during the wet season than in those that died during the dry months. The highest *Haemonchus* burden from a single animal at autopsy (> 5000 worms) was from a goat while sheep did not appear to tolerate more than 2500 adult worms.

The seasonal trend of *Trichostrongylus* infection was similar to that of *Haemonchus*, with somewhat higher burdens in sheep than in goats in contrast to the results from the faecal cultures. *O. columbianum* and *B. trigonocephalum* were only recovered from animals that died during the wet season and almost exclusively from traditionally managed animals. *T. ovis* was only occasionally present and then only during the wet season. *M. expansa* showed no seasonal trend. Intermediate stages of dog tapeworms were occasionally seen both in sheep and goats.

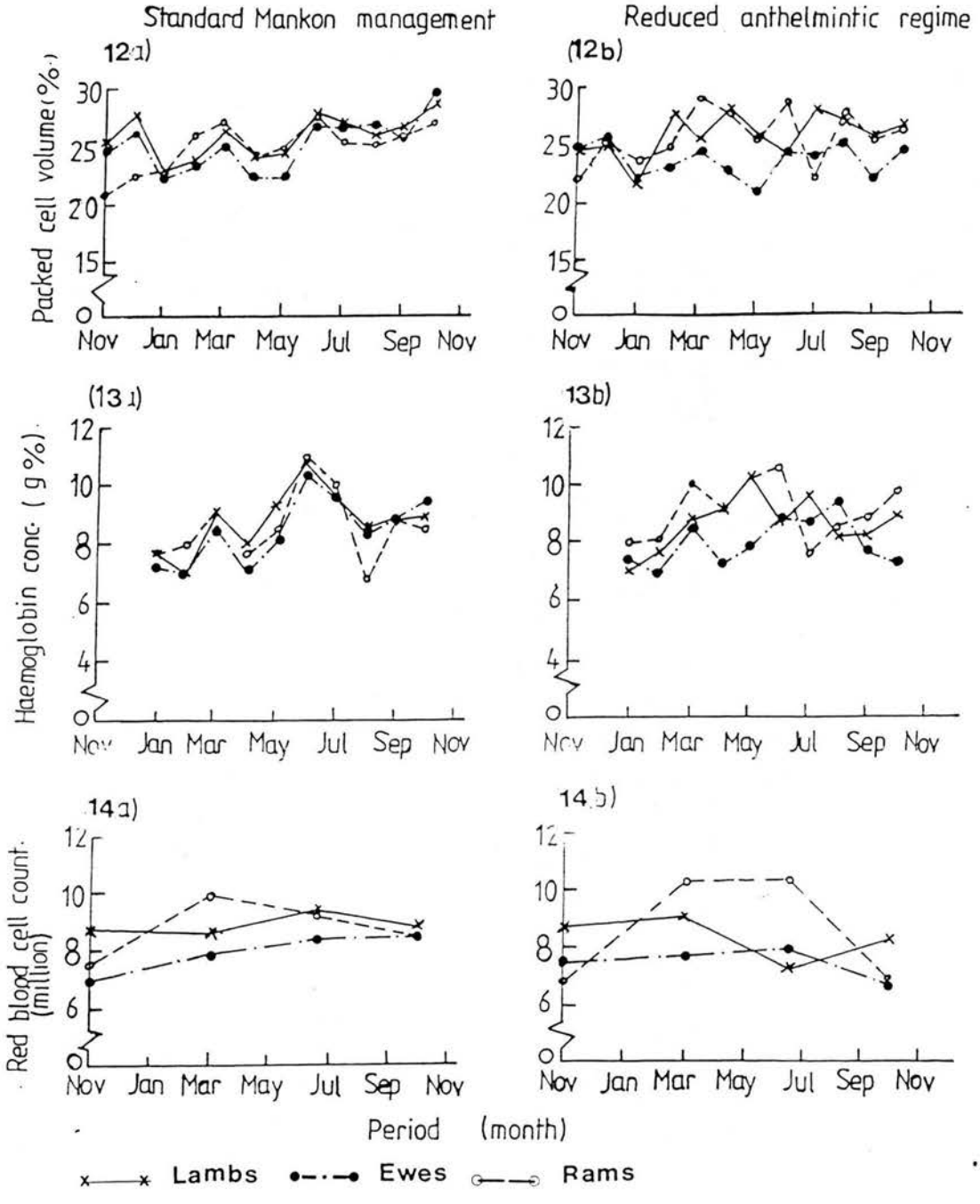
Haematology

Sheep: The changes in packed cell volume (PCV), haemoglobin concentration (Hb conc.) and red blood cell (RBC) count of sheep under standard and reduced anthelmintic regimes are shown in Figures 12-14 and in Appendix 3. The Hb concentration in the animals at Mankon was abnormally high in November and December so that only data after this time is presented in Figure 13. The pattern of changes in the haematological values of the lambs, ewes and rams under the standard management was similar throughout

Table 25 Post-mortem worm counts in sheep in N.W. Province of Cameroon 1984-1985

Period (month)	Type of animal	Group	Animal No.	Mean number of worms per infected animal H. contortus	T. axei	T. colubr.	B. trigo.	S. papill.	O. columb.	Trichu. ovis	M. expansa	Meta-cestodes
Jan.	Goat	S	201	700	–	700	–	–	–	–	5	–
	Sheep	S	17	360	10	26850	–	–	–	–	–	–
April	Sheep	R	81-64	4140	1750	135000	–	–	–	–	–	+
	Goat	S	214	–	–	600	–	–	–	–	–	–
	Goat	R	213	150	–	300	–	–	–	–	–	+
	Sheep	T	45	4300	3700	18250	–	–	–	–	–	+
July	Sheep	T	230	1710	200	12500	50	–	14	–	10	–
	Sheep	T	234	10	2600	13700	250	–	12	–	–	–
	Sheep	T	46	100	1800	28350	210	–	636	2	2	–
	Sheep	T	235	1090	700	4800	800	250	48	–	2	–
Aug.	Sheep	S	84-09	–	–	–	–	–	–	–	–	–
	Sheep	T	30	1650	900	10050	320	50	307	7	1	–
	Goat	T	18	5850	2900	1650	–	–	251	30	–	–
	Sheep	R	81-52	1040	100	34750	–	–	11	–	–	–
Sept.	Sheep	S	82-26	50	220	10	–	–	–	–	–	–
	Sheep	T	53	2360	2560	35000	420	–	39	1	3	–
	Sheep*	S	307	2080	–	1550	–	–	–	–	–	+
Oct.	Goat	R	127	5720	–	26600		–	–	–	–	–

*Culled; S = Standard regime; R = Reduced anthelmintic regime; T = Traditional management;
T. colubri. = T. colubriformis; B. trigo. = B. trigonocephalum; S. papill. = S. papillosus;
O. columb. = O. columbianum; Trichu. ovis = Trichuris ovis



Figures 12-14 Changes of packed cell volume (Fig. 12), haemoglobin concentration (Fig. 13) and red blood cell count (Fig. 14) in sheep under two management systems.

the year. The PCV and Hb values (Figures 12 and 13) displayed a similar pattern of changes and the correlation between them was significant in lambs ($r = 0.730$, $P < 0.05$) and ewes ($r = 0.786$, $P < 0.01$).

In both management systems, there was overall little clear trend and no evidence of frank anaemia. There was a significant increase in both PCV ($P < 0.001$) and Hb concentration ($P < 0.01$) in animals on the standard regime at the beginning of the rains to a peak in June. The PCV showed little change with time while the Hb concentration tended to be higher during the rains. These parameters fluctuated more widely in animals on the reduced anthelmintic regime (Figures 12b and 13b) than in those on the standard regime (Figures 12a and 13a). The fluctuations did not correlate with treatments. There were no marked or consistent changes in RBC counts throughout (Figure 14).

The MCH values were significantly higher ($P < 0.05$) in all animals on the standard regime and in lambs on the reduced anthelmintic regime in mid-July than in March and October (Appendix 4). The changes in MCV and MCHC were not significant despite the overall trend of higher values for these parameters in October and mid-July respectively (Appendix 4). The WBC counts exhibited overall little clear trend with values fluctuating between 7,350 and 11,780 cells per cmm of blood (Figures 15a and 16a). The values were not significantly different in lambs, ewes and rams of either management group.

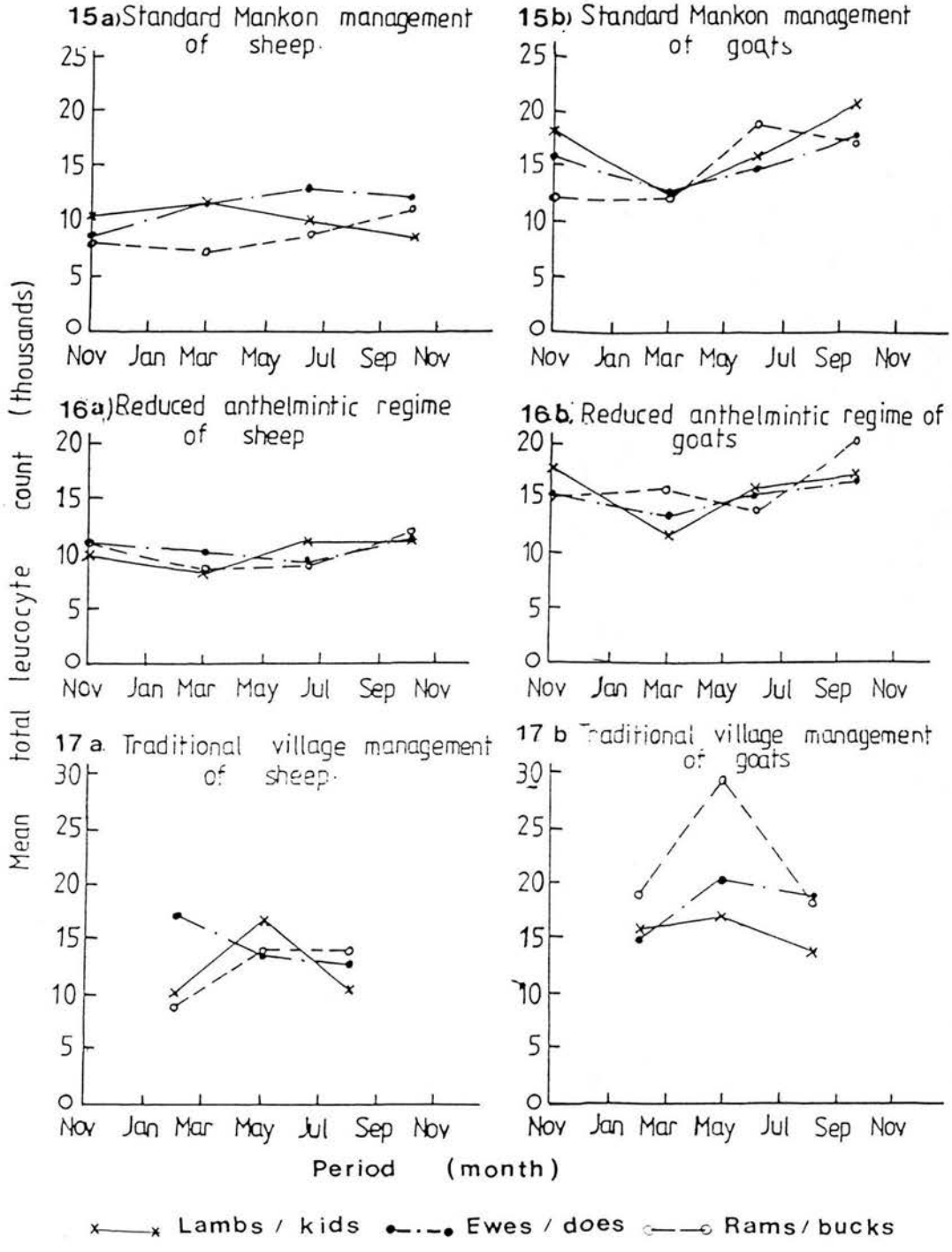
In the traditionally managed sheep, the PCV, Hb concentration and RBC values tended to decline overall, with a possible, though insignificant, temporary increase in the Hb concentration of lambs in the early part of the rains (Figures 18a-20a).

Goats: The changes in PCV, Hb concentration and RBC counts of goats under the standard and reduced anthelmintic regimes are shown in Figures 21-23 and in Appendix 3.

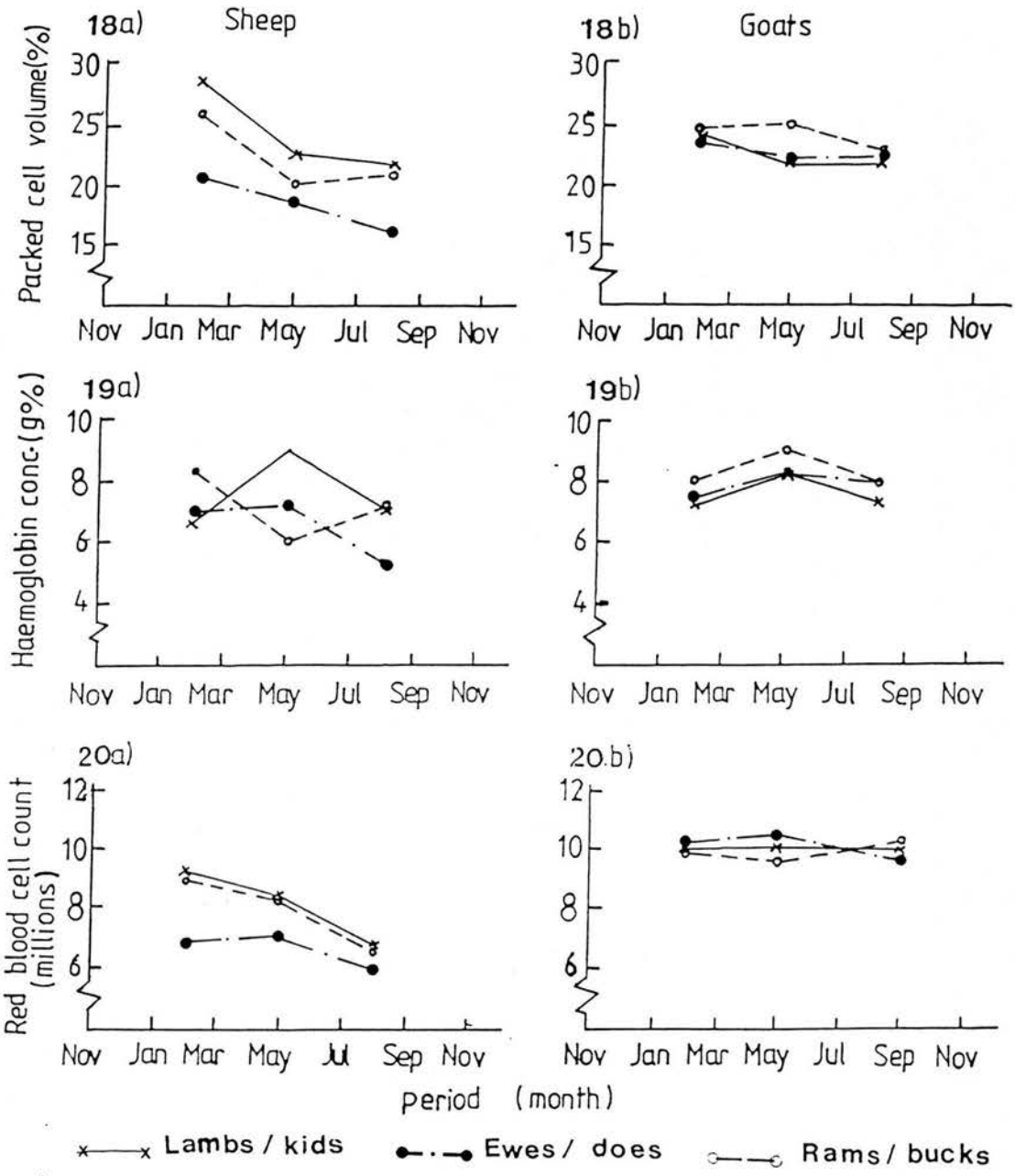
The groups at the research station showed a significant decline ($P < 0.001$) of PCV between November and February but then slowly recovered (Figure 21) and remained fairly constant thereafter.

The Hb values in the goats at Mankon followed a similar pattern to the PCV (Figure 22). The values tended to be low during the dry season. The correlation between the PCV and Hb values was found to be positive but not significant except in the kids in the standard management group ($r = 0.64$, $P < 0.05$).

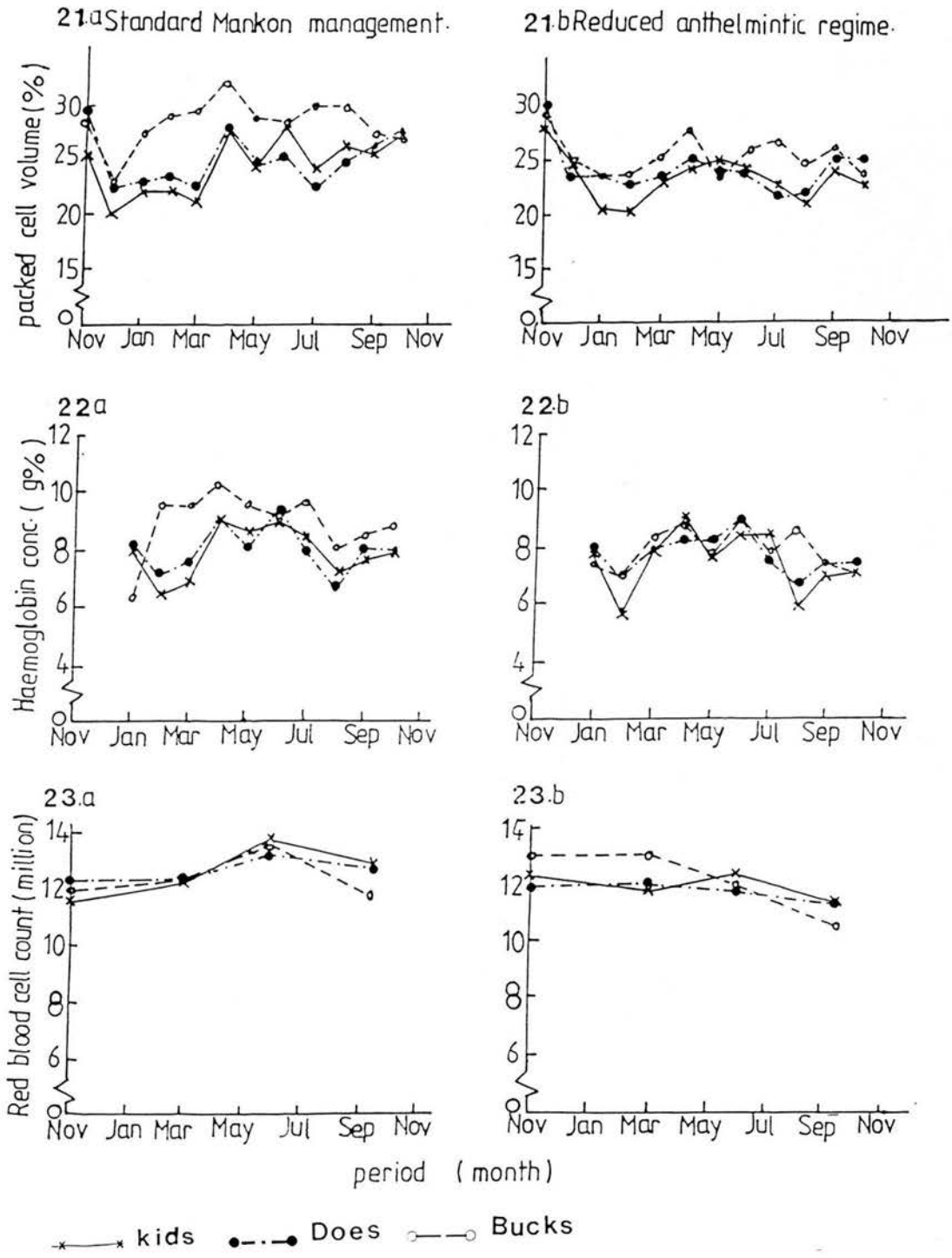
There was little overall change in the RBC count of goats in the



Figures 15-17 Mean total leucocyte counts in sheep and goats under standard Mankon management (Fig. 15), reduced anthelmintic regime (Fig. 16) and traditional village management (Fig. 17).



Figures 18-20 Changes of packed cell volume (Fig. 18), haemoglobin concentration (Fig. 19) and red blood cell count (Fig. 20) in sheep and goats under traditional village management.



Figures 21-23 Changes of packed cell volume (Fig. 21), haemoglobin concentration (Fig. 22) and red blood cell count (Fig. 23) in goats under two management systems.

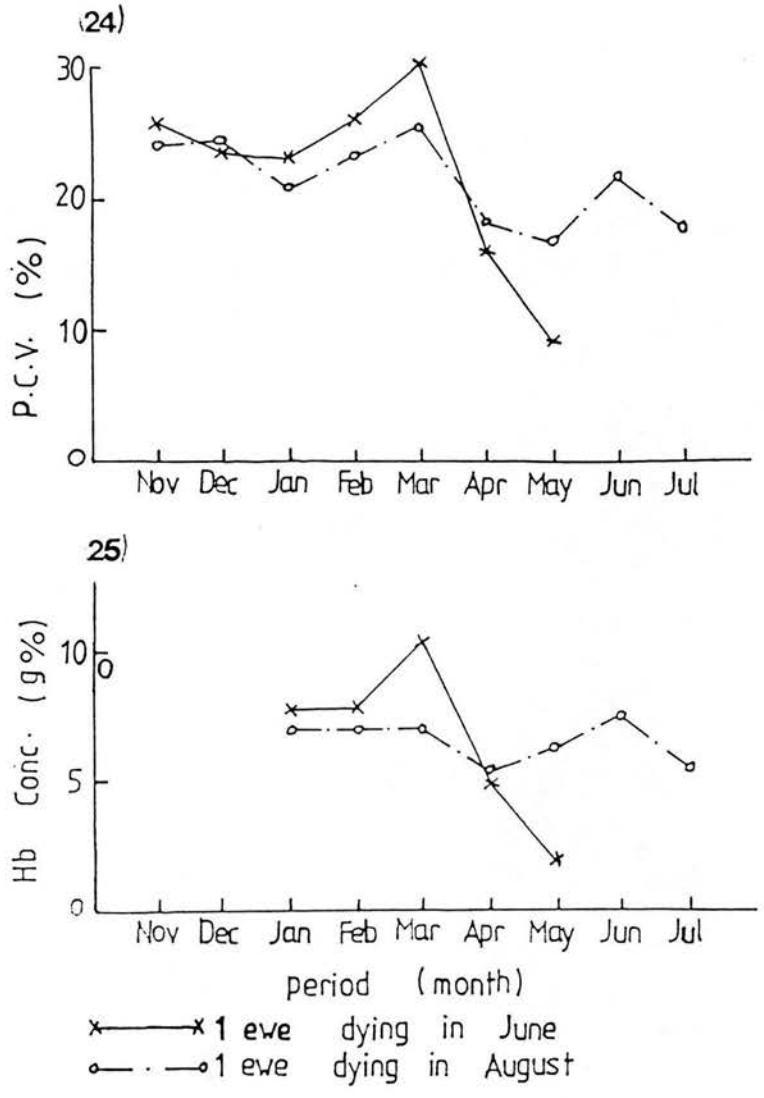
standard group and may be a slightly downward trend in the reduced group (Figure 23). Significantly higher counts of white blood cells ($P < 0.01$) were recorded during the rainy season than during the dry season (Figures 15b and 16b). The MCV values were comparatively lower in March than in the other months (Appendix 4). On the other hand, the lowest values of MCHC were recorded in October. These differences were, however, not significant.

In the traditionally managed goats, the haematological values closely reflected the values in the goats at the research station except that they were generally lower (Figures 18b–20b). There was overall little change in the values throughout the year.

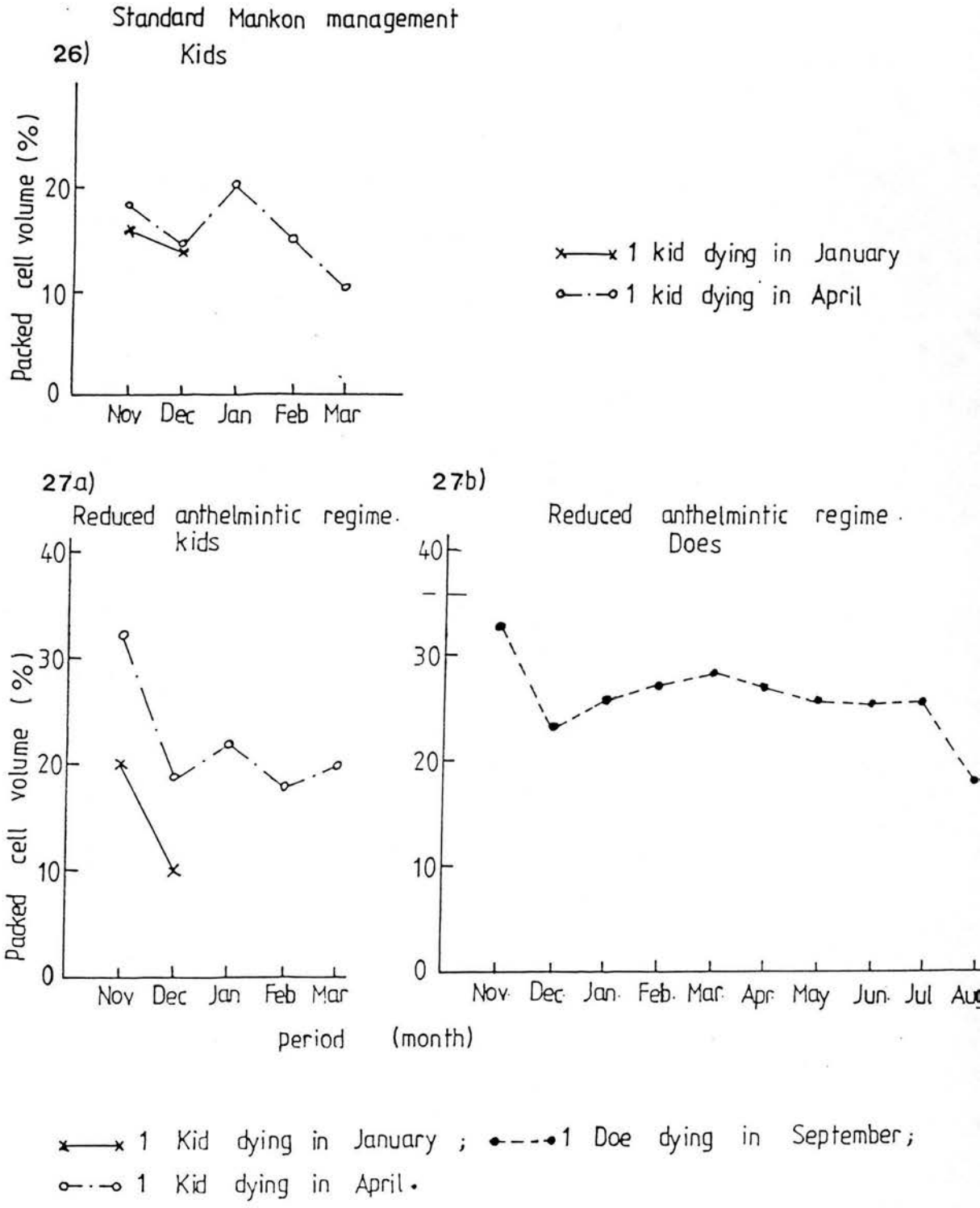
Figures 24–27 show the changes in PCV of the sheep and goats that died during the experiment. Most of the animals showed a rapid terminal decline. However, in some of the animals this was temporarily offset by the general rise in PCV that occurred at the onset of the rains in March. In animals that died after June, the decrease in PCV was less rapid than in animals dying earlier. The Hb values followed a similar pattern to the PCV.

Although the PCV and Hb values of sheep and goats were not significantly affected by age and sex, the values tended to be lower in kids than in adult goats and in ewes than in lambs and rams. RBC values were much lower in sheep than in goats, while MCV and MCH values were significantly ($P < 0.01$) higher in sheep than in goats and MCHC values were similar. White blood cell counts were significantly ($P < 0.01$) higher in goats than in sheep. The haematological values, especially PCV and Hb concentration, were generally somewhat lower in goats on the reduced anthelmintic regime than in those on the standard regime, but the difference was not significant. Sheep on the two regimes had similar haematological values. The packed cell volume was generally and significantly lower during the rainy season in the traditionally managed sheep ($P < 0.01$) and goats ($P < 0.01$) than in those at the research station.

The correlation between faecal egg counts and PCV of sheep on the standard management was negative and significant in lambs ($r = -0.549$, $P < 0.05$) and ewes ($r = -0.741$, $P < 0.01$). More surprisingly the correlation was positive and significant in kids on standard management ($r = 0.559$, $P < 0.05$). The animals whose faecal egg counts showed a significant correlation with PCV also showed a positive correlation between PCV and Hb concentration (lambs: $r = 0.730$, $P < 0.05$; ewes: $r = 0.786$, $P < 0.01$; kids: $r = 0.641$, $P < 0.05$).



Figures 24-25 Changes of packed cell volume (Fig. 24) and haemoglobin concentration (Fig. 25) in ewes dying during the experiment.



Figures 26-27 Changes of mean packed cell volume in goats dying during the experiment.

Serum biochemistry

Sheep: The results showed significant seasonal variations in total serum protein and serum protein fractions (Figures 28 and 29, Appendix 3). Generally the total protein and globulin values were lower in lambs than in either ewes or rams, the difference being significant in April ($P < 0.01$) and June ($P < 0.05$) for animals on standard management (Figure 28a). The total protein concentration fell slightly during the dry season but was significantly elevated in ewes ($P < 0.01$) and rams ($P < 0.05$) from April. There was no significant difference in the total protein values of the animals under the standard management (Figure 28a) and reduced anthelmintic regime (Figure 29a).

The serum albumin values (Figures 28a and 29a) did not change significantly throughout the year. The globulin concentration, on the other hand, was elevated in sheep under both management systems throughout the rainy season except for an insignificant drop in September (Figures 28a and 29a). This increase was significant only in the rams and ewes ($P < 0.05$).

The albumin-globulin (A/G) ratio (Figure 30) fluctuated throughout the year in sheep under both management systems at the research station with a slight overall tendency to fall. In some of the groups the ratio fell during the dry season from November to February; thereafter there was little difference between any of the groups. None of these changes correlated with treatment.

The serum pepsinogen concentrations (Figure 31, Appendix 3) remained low between November and February, then tended to rise from March to a peak in August, this change being significant in lambs ($P < 0.05$) under both management systems and in ewes ($P < 0.05$) and rams ($P < 0.01$) on the reduced anthelmintic regime. The concentrations then tended to fall under both management systems.

In the traditionally managed sheep, the values of total protein, albumin and globulin did not change significantly at any time (Figure 32a). The serum pepsinogen values tended to be higher in May than in either February (except for the lambs) or August (Figure 32b).

Goats: The pattern of changes in the serum total protein and protein fractions of goats under the standard and reduced anthelmintic regimes is shown in Figures 28b and 29b and Appendix 3. In general the total protein values rose steadily until August from low levels at the start of the experiment. After August there was a significant drop ($P < 0.01$) in value in animals on standard management (Figure 28b).

In animals on the reduced anthelmintic regime (Figure 29b) the albumin

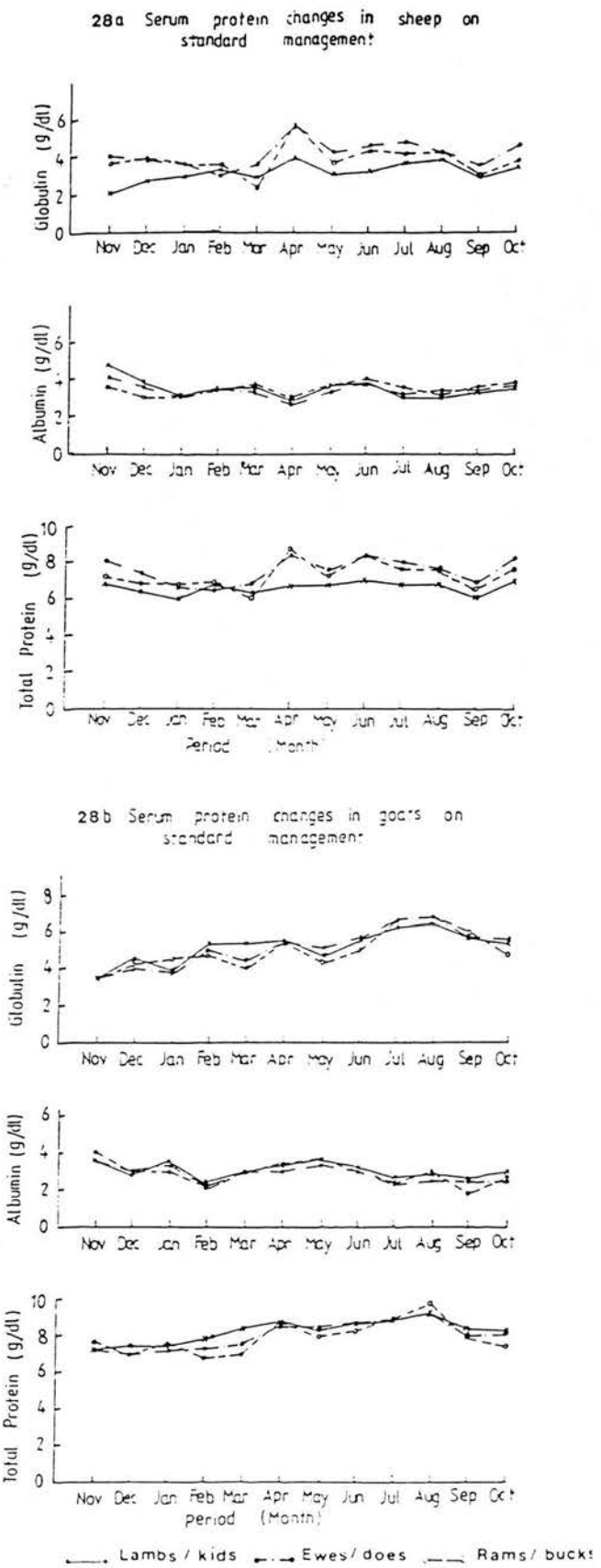


Figure 28 Serum protein changes in sheep (Fig. 28a) and goats (Fig. 28b) under standard Mankon management.

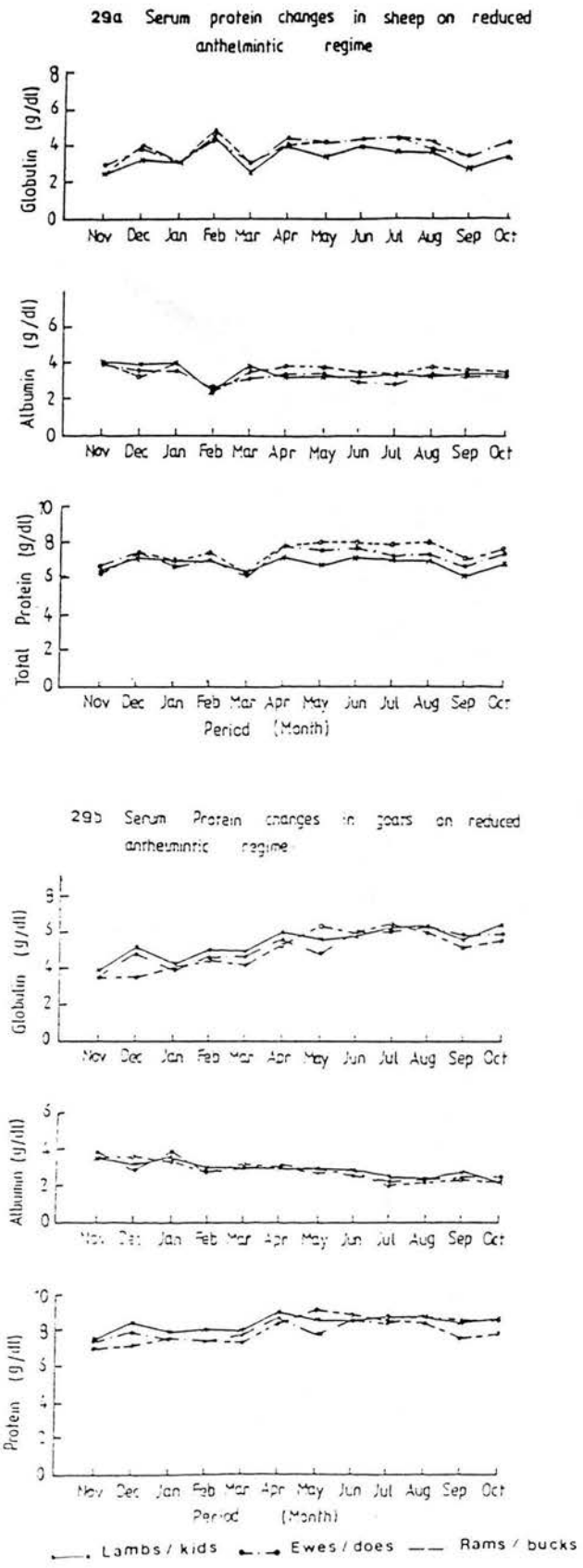


Figure 29 Serum protein changes in sheep (Fig. 29a) and goats (Fig. 29b) under reduced anthelmintic regime.

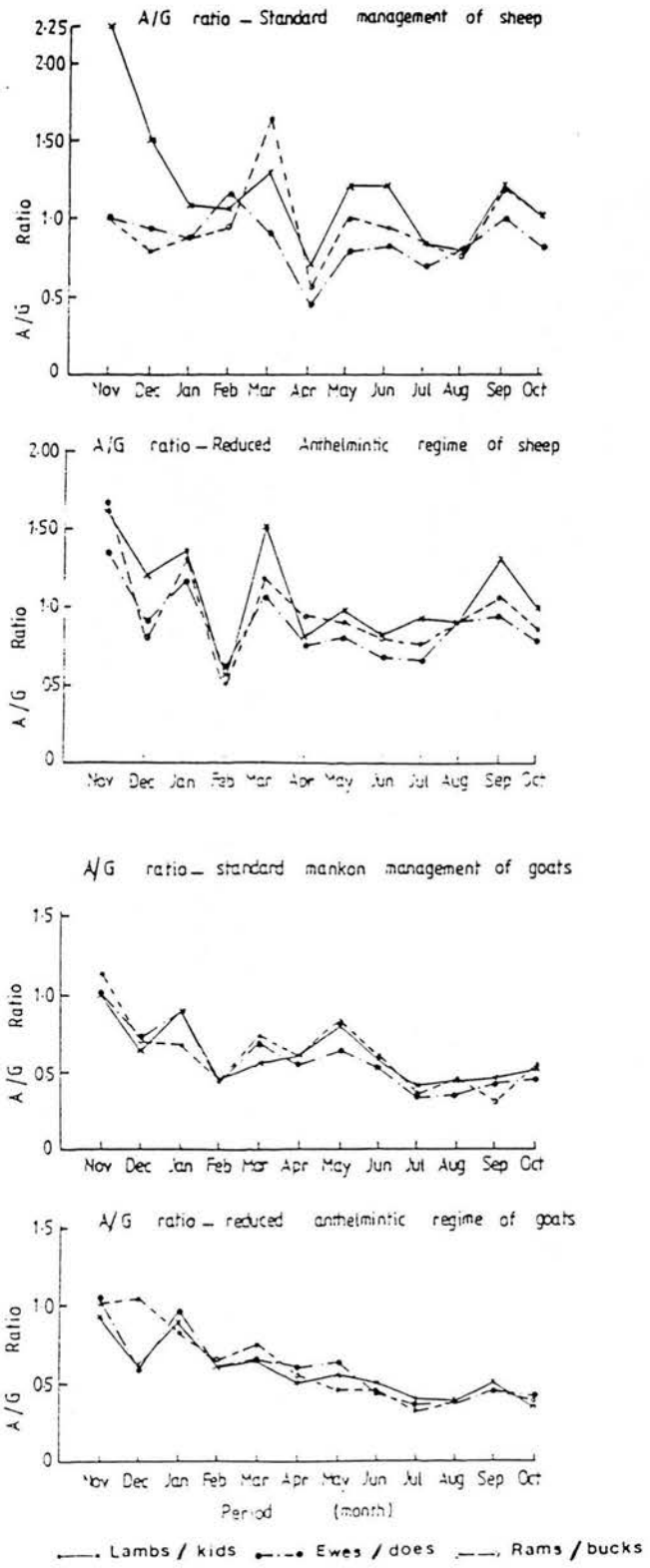


Figure 30 The average albumin/globulin (A/G) ratio of sheep and goats under standard Mankon management and reduced anthelmintic regime.

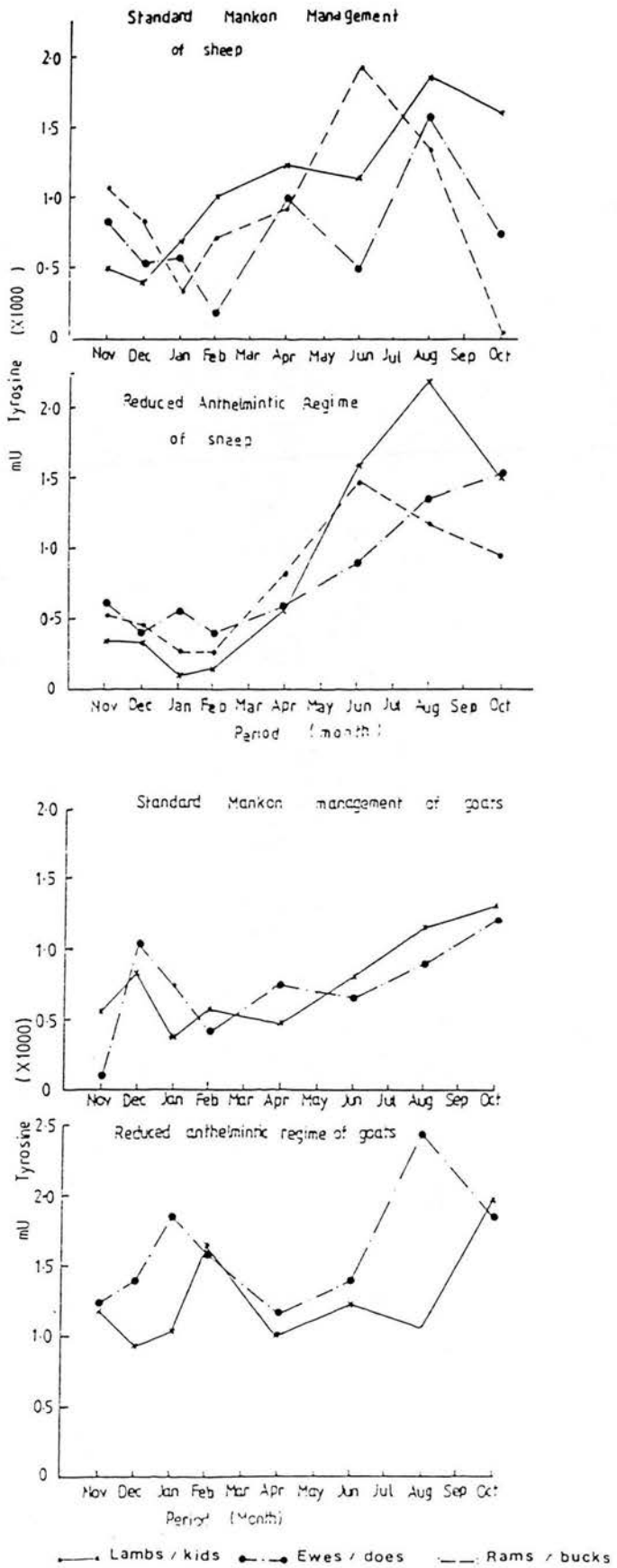


Figure 31 Serum pepsinogen assay of sheep and goats under standard Mankon management and reduced anthelmintic regime.

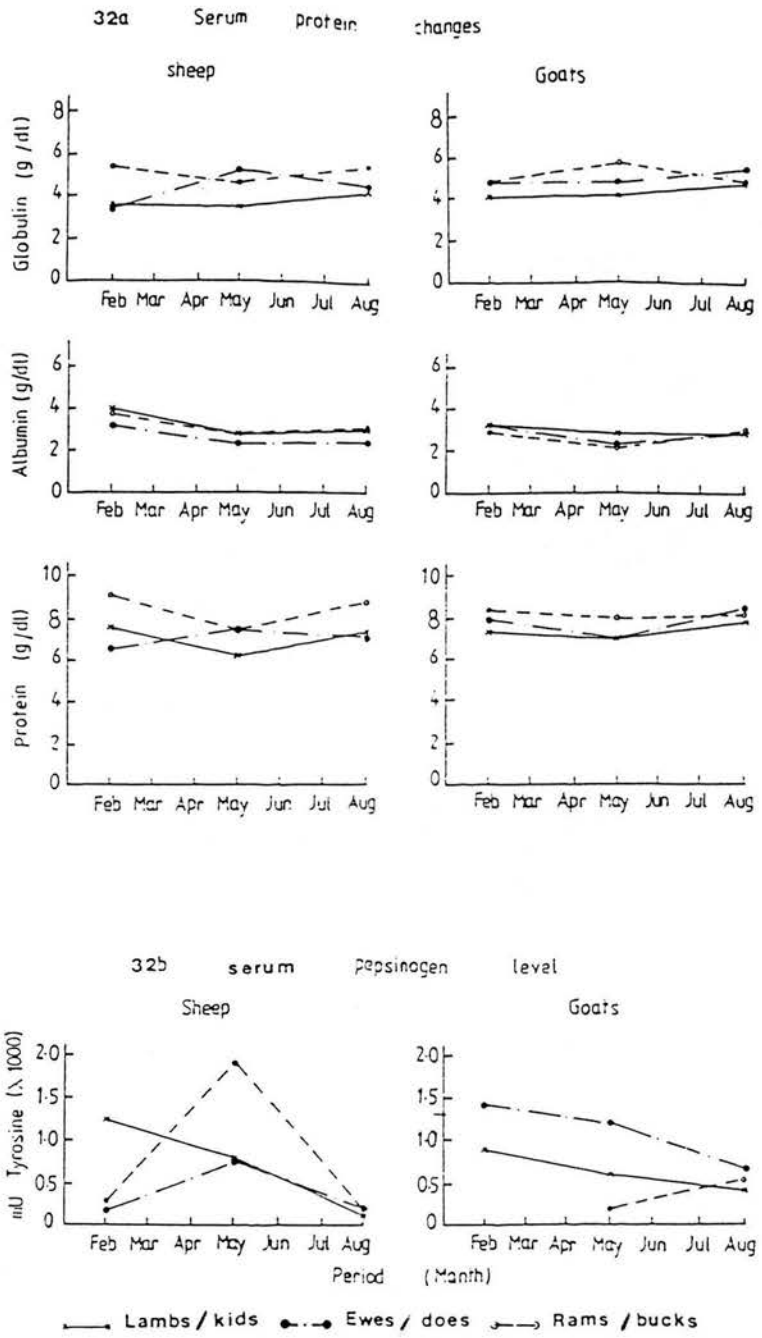


Figure 32 Serum protein changes (Fig. 32a) and serum pepsinogen level (Fig. 32b) in sheep and goats under traditional village management.

concentration showed a more or less steady fall throughout the study. In animals on the standard regime (Figure 28b) the fall was less consistent with some tendency to recover during the period from February to May.

The pattern of changes in the globulin concentrations (Figures 28b and 29b) was similar to that of the total protein in that the values increased slightly from December to a peak in August before dropping.

There were no significant differences in the concentrations of total protein, albumin and globulin of kids, does and bucks under either management system or between the two management systems at Mankon.

In goats on monthly and reduced anthelmintic treatments, the albumin-globulin ratio fell fairly steadily throughout the study reflecting the overall tendencies in the total protein and albumin values.

The serum pepsinogen concentration (Figure 31 and Appendix 3) was significantly ($P < 0.05$) elevated in December and January but dropped towards the end of the dry season. From April the level increased significantly ($P < 0.01$) for animals on both regimes. The concentration remained above 1000 mU almost throughout in animals under the reduced regime. By contrast the value was elevated above 1000 mU in animals on standard management only from August.

The total protein, albumin and globulin values of traditionally managed goats (Figure 32a) did not vary significantly. The serum pepsinogen level showed a progressive decrease in kids and does (Figure 32b). Higher levels were recorded in does than in kids but the difference was not significant.

The correlation between faecal egg counts and serum pepsinogen levels was found to be positive but not significant in goats under both management systems at Mankon. It was also positive but not significant in rams under both management systems at Mankon, in ewes under the reduced anthelmintic regime and in the traditionally managed sheep.

DISCUSSION

The climatic and other environmental conditions around Bamenda are suitable for the development of the extra-host stages of trichostrongyles throughout most of the year (Williamson and Payne, 1978). The high ambient temperatures give rapid development while the high rainfall for about eight months of the year increases the survival rate of these stages. Moisture is the limiting factor for larval survival since temperatue conditions are suitable throughout the year. The presence of tall herbage on the pastures provides relatively favourable conditions for survival and development of the eggs even

during most of the dry season.

Productivity and Parasitology

The results of the epidemiological study carried out in 1984–85 showed that even using an anthelmintic to which the parasites were resistant, a strategic anthelmintic regime involving 4–5 doses of anthelmintic a year could give similar results in terms of productivity to the previously used standard regime of monthly dosing. This applied to all stock, both young and adults. As only a single dose is needed at the onset of the dry season, this could allow a saving of eight doses of anthelmintic per animal per year. Chiejina and Emehelu (1986) obtained significantly improved weight gains and a considerable reduction in pasture contamination following strategic dosing of three groups of intensively managed N'dama cattle at Nsukka, Nigeria in a similar but somewhat warmer climatic zone.

The study also revealed that at Mankon, the goats gained considerably less weight and from May to November, the faecal egg counts from sheep were consistently lower than those from goats. This did not occur with the traditionally managed animals where goats gained considerably more weight than the sheep and the faecal egg counts from sheep remained consistently higher than those from goats. It was thought that the poor growth rate in the goats at Mankon might have been related to the fact that they were forced to graze and largely denied the browsed fodder which constitutes a major part of their natural diet. Schillhorn van Veen (1982) suggested that browsing behaviour reduces the chances of acquiring pasture-transmitted parasite infections and there is good evidence that goats usually have a lower infection rate with trichostrongyles than sheep (Anderson and Christofferson, 1973). However the rotation of the goats on their smaller paddocks which could not be avoided for administrative reasons may have led to them grazing pasture which was more heavily contaminated with infective larvae than the set-stocked sheep paddocks. Several studies have shown that in some circumstances rotational grazing can result in an increased number of infective larvae on the pasture, higher worm burdens in grazing animals and reduced weight gains, as compared with a set-stocking system (Levine and Clark, 1961; Ciorda *et al.*, 1964; Hotson, 1967; Donald, 1968; Gibson and Everett, 1968; Michel, 1969; Levine *et al.*, 1975; Armour, 1980). Regrowth during the period that the pasture is not grazed may provide a more favourable environment for larval survival and translation. Animals set-stocked on pasture tend to graze it low thus reducing the herbage height and to trample and/or scatter the faeces,

so exposing the free living stages to changes in temperature and humidity and this may result in increased mortality of larvae and reduced translation.

It should, however, be noted that the mean liveweight gains in the adult female goats at Mankon may have been confounded by the parturitions that occurred in November shortly after the commencement of this study. This probably affected the initial weights and hence the final weight gains recorded for the kidding does.

In contrast to the performance of sheep at Mankon, the traditionally managed sheep performed poorly compared to the traditionally managed goats. The poor performance of the sheep may indicate that when they are under nutritional stress, because they are less inclined to browse or less able to utilize browse, they are more susceptible to helminth infections. The goats under village conditions appear to be protected by their browsing behaviour which reduces their chances of picking up infections. The absence of treatment may then have resulted in the high mortality in the sheep.

In both sheep and goats, faecal egg counts generally remained low between December and April, regardless of the frequency of treatment. Even in the traditionally managed animals, where no treatment was given, faecal egg counts were reduced at the beginning of the dry season. Pasture larval counts and infection levels in tracer animals were similarly low during this period. This reduction in faecal egg counts may be attributed to two main factors:- (1) the absence or greatly reduced rate of reinfestation and (2) coincidental reduction in the egg laying capacity of the existing adult worms, possibly associated with their age or with the hosts's nutrition.

Hypobiotic larvae were not found in tracer animals grazed on pasture during the dry season. Chiejina (1986) observed for the situation in Nigeria that there may be a significant fall in percentage inhibition of *Haemonchus* spp. from north to south of the country. This suggests that factors such as rainfall, relative humidity, dryness or other stimuli which show marked seasonal variation as well as north-south differences are involved. This phenomenon of larval inhibition needs further study especially as the climatic conditions in the North West Province of Cameroon are such that one would expect at least a very reduced rate of arrested larval development at the end of the rains and very early in the dry season.

The development and survival of eggs within faecal matter are dependent on temperature and moisture (Armour, 1980). Between December and March there was virtually no rain and any moisture from the last rains in

November had largely dried up. These conditions largely preclude egg and larval survival. The results from worm counts in the tracer animals indicated that pasture infectivity is negligible during the dry season. The surviving ensheathed L_3 larvae persist in the soil, mat or faecal pellets and animals probably pick them up when they graze on very short herbage. The high herbage in Bamenda area may permit some survival of a few infective larvae to occur throughout the year but it occurs much more readily during the rainy season. Rainfall is thus the major determinant of the availability and transmission of the strongylid nematodes of small ruminants in the savanna zone of Cameroon. This is confirmed by the observations of Enyenihi (1969) and Fabiyi (1973) in Nigeria although the environment does not appear quite as deleterious for larvae in the savanna area in North West Province of Cameroon as in the northern Nigerian savanna. It also supports the observations of Chiejina (1986) in the southern savanna of Nigeria.

The seasonal pattern of larval availability on pasture as observed in the 1984-85 epidemiological study revealed that with the onset of the rains, the environmental conditions become favourable for larval survival. The rise in egg counts obtained in the early rainy season was probably from the residual adult worms, increased later by worms developed after the infection by larvae derived from eggs that have developed quickly to produce the first wave of larval contamination of the pastures reached under all the management systems by about mid-June. This resulted in a heavy infection rate as reflected in the worm burdens of the tracer animals. The mortalities, especially among the traditionally managed sheep, in July, August and September coincided with the period of heaviest larval challenge. The greater mass of herbage plus a washing-off effect at the height of the rains probably tended to reduce the concentration of larvae between August and October. As the rains ceased and the growth slowed, there was a further increase in larval contamination towards the end of the rains.

Faecal larval cultures and differentiation indicated a greater contamination of sheep pastures with *Haemonchus* larvae than with *Trichostrongylus* larvae. This implies that a higher proportion of the total burden in the sheep was *Haemonchus* than was the case for the goats but will also reflect that *Haemonchus* is much more fecund than *Trichostrongylus* (Fabiyi, 1973). A comparison of these results with the findings from post-mortem examinations indicates that the results from larval cultures are more a reflection of fecundity of the worms than burden.

The studies using tracer animals indicated that *Haemonchus* was present throughout the year and probably survives the relatively short and mild dry season in the North West Province of Cameroon as adult parasites in the host or as infective larvae on the pasture (Schillhorn van Veen, 1982). Peak burdens in tracer animals occurred in May and September for sheep and August for goats. Peak burdens of *Trichostrongylus* were attained in May and September for sheep and July for goats. Since the periods of peak burdens of *Haemonchus* and *Trichostrongylus* more or less coincide for each host species, one may deduce that the deaths resulted from a combination of haemonchosis and trichostrongylosis. This is supported by haematological findings. The results from post-mortem examination confirm that high counts of *Haemonchus* were usually accompanied by high counts of *Trichostrongylus*. Fabiyi (1973) suggested that the optimal climatic conditions for preparasitic survival of *Trichostrongylus* may be similar to those for *Haemonchus* in Nigeria. The findings in this study indicate that this may also be true for Cameroon. However, the pattern of infection in the tracers (Figure 11) suggests that *H. contortus* has more of its infective larvae being available on pasture during the dry season than *Trichostrongylus*. This implies that although *Trichostrongylus* has two desiccation-resistant stages (larvated eggs and the ensheathed L_3 larvae) while *Haemonchus* has only one (ensheathed L_3 larvae) (Anderson and Levine, 1968), the high fecundity constant of *Haemonchus* enables the latter to leave more surviving infective larvae on pasture at the end of the rains than *Trichostrongylus*. The surviving larvated eggs of *Trichostrongylus* only become significant in increasing the contamination rate of the pastures by the latter at the beginning of the rainy season.

Since *O. columbianum* and *B. trigonocephalum* were virtually absent from the pastures between January and March, it appears that these species are not resistant to the desiccation associated with the dry season. Fabiyi (1973) also observed that *Oesophagostomum* spp. shows the greatest abundance in the savanna belt of Nigeria in the late wet season. The burdens of these two species that were observed at post-mortem examination of animals that died in December 1985 and January 1986 (Appendix 10) were probably acquired in the late rainy season, again emphasizing the value of early dry season treatment. Since they were found in some of those animals in numbers that may be fatal (Skerman and Hilliard, 1966), they were probably the main pathogens associated with the parasitic gastroenteritis in these

animals.

The level of anthelmintic resistance in the nematode parasites in the sheep and goats at Mankon was such that the regular use of a benzimidazole, as in the standard regime used in, and before, 1984/85 was valueless. It is therefore not surprising that the rationale for the reduced anthelmintic regime at Mankon appears to have worked out well despite the suboptimal management of the goat pastures.

Haematology

The scarcity of good pasture during the dry season probably poses a nutritional stress on the animals. This nutritional stress coupled with the effect of the residual worm burdens may have been responsible for the lowered blood values between December and March. Sheriff and Habel (1976) observed that while the nutritional level alone does not greatly affect red blood cells, some parasites reduce the erythrocyte parameters to a greater extent in undernourished than in adequately fed sheep.

With the onset of the rains from mid-March, helminthiasis becomes a more important problem. One effect of removal of blood by blood-sucking parasites, such as *H. contortus*, is to stimulate the blood forming organs into increased activity (Veglia, 1915) which may even give a temporary apparent polycythaemia (Fourie, 1931; Pradhan and Johnstone, 1972). This could explain the initial rise in the blood values, especially the packed cell volume and haemoglobin concentration, which was observed from March under all management systems. The later fall in the blood values is consistent with the greater demands of the L_5 larvae and developing adults, the number of which increased considerably as infective larvae were being picked from the pasture at an increasing rate, allied to the more efficient blood-letting associated with the lancet formation. Oshio (1952) suggested that the anaemia and emaciation of goats and sheep heavily infected with *Haemonchus* is caused not only by the worms sucking blood from the hosts but also because there is an anaemia-producing substance in the serum of the infected animals and in the worm's body.

The host's response to the effect of these heavy worm infections at the onset of the rainy season was reflected in the increased blood values observed in May and June. Progressive anaemia then developed soon after that again corresponding to a period of heavy infections on the pasture and in the animals as indicated by the high strongyle egg counts, pasture larval counts and worm burdens in tracer animals and carcases. The greater

helminth challenge in the traditionally managed sheep, as shown by the high faecal egg counts and heavy worm burdens at necropsy, may have been responsible for the consistent drop in blood values in these animals as the rainy season advanced. Fourie (1931) remarked that a progressive decrease in RBC counts will result when the bone marrow is no longer fully able to meet the demands on it. WBC values appeared to be related to the level of parasitic infection, being significantly elevated during the rainy season when worm burdens are high.

Generally the MCV values were lower in the dry season than in the rainy season, especially in the goats at Mankon in 1984–85, which were exposed to heavy helminth challenge during the rainy season. Dobson (1967) similarly observed a change in MCV and MCHC values in heavier infections with *Oesophagostomum columbianum*.

The RBC, PCV and Hb values reported for sheep and goats in this study agree with those given by Oduye (1976) and were all generally low compared to normal values reported in this study elsewhere. Oduye (1976) attributed the low erythrocytic values of Nigerian sheep and goats to a low intake of iron or to slow but continuous loss of blood due to blood sucking abomasal parasites, e.g. *H. contortus*, and blood parasites which are common in Nigeria all year round. Cabaret and Planchenault (1986) obtained mean erythrocytic counts of 9.03 x 10^6/cmm (range 6.36–12.84 x 10^6) and haematocrit values of 33.7% (range 22–55%) for the Zaian sheep breed of Morocco and attributed the seasonal variations to the effects of worm burdens and nutritional status of the animals.

Where the faecal egg counts and PCV were shown to be negatively correlated, it would appear that the worms were removing red cells faster than the animal could replace them. Whitlock (1955) was the first to present data which showed a depression in the haematocrit to be directly related to logarithmically transformed *H. contortus* egg counts, an observation that was later confirmed and expanded by Whitlock (1961, 1963), Conway and Whitlock (1964) and Whitlock *et al.* (1966, 1972).

As the seasonal pattern of the haematological values was similar between the standard and reduced anthelmintic regimes of each species, it would seem that the use of fewer anthelmintic treatments may be preferred for the economically optimum productivity by small ruminants without any major risk of increasing the incidence of disease and with some possibility of retarding the selection of resistant strains of helminth parasites.

Serum biochemistry

The results presented here indicate significant seasonal variations in total serum proteins and protein fractions of sheep and goats on pasture. The serum protein values were generally lower during the dry season and were also lower in sheep than in goats. These low total protein concentrations may be related to the poor quality of the pastures (high in lignin and low in protein) at this time (Williamson and Payne, 1978). The low levels of total serum protein and albumin may also be attributed to the direct effects of the parasites on the host (Kuttler and Marble, 1960).

The total protein and globulin values were observed to be generally lower in lambs and kids than in adults. Since none of the animals in the present study were parasite-free, it is possible that the lower values observed for total protein and globulin in lambs and kids may be partly related to their greater susceptibility to parasitic infections.

In both sheep and goats there was an increase in the total protein and globulin values with a corresponding small decrease in albumin concentration during the rainy season. In some instances this was preceded by an initial decrease in the total protein and globulin values only in the wet season (Figure 29a). These changes coincided with the general rise in faecal egg counts in all animals. The initial fall in protein level was probably as a result of loss due to parasitism. The host's attempt to compensate for the loss led to the rise in serum globulin and hence in total protein. The increase might also have been a possible indication of resistance of the animals against the infection (Raisinghani *et al.*, 1971).

There was no marked species difference in the seasonal variations in the total serum protein, albumin or globulin levels. There was no significant difference observed in the values of these parameters between animals of the same species on the standard and reduced anthelmintic regimes.

In the goats at Mankon, the albumin-globulin ratio fell fairly steadily throughout the study. Since these animals were more heavily parasitized than the sheep, especially throughout the wet season, it is probable that the A/G ratio changes were a direct result of parasitic infections. In the sheep on the standard and reduced anthelmintic regimes which maintained a comparatively low level of helminth infection, the A/G ratio showed a pronounced decrease only in April and then fluctuated at a higher level than in goats.

Serum pepsinogen levels were significantly elevated in sheep and goats during the rainy season and this may be an indication of the level of worm

burdens in the animals at this period. Thomas and Waller (1975) noted that serum pepsinogen concentration was directly related to abomasal damage and was a much earlier indicator of worm build-up than faecal egg counts. Several other workers including Brunsdon (1972) and Kerboeuf (1980) have demonstrated a significant correlation between pepsinogen level and total worm burden. However, there was no significant correlation between serum pepsinogen concentrations and faecal egg counts in the present study, which confirms earlier observations of Hotson (1967) and Mylrea and Hotson (1969).

ANTHELMINTIC RESISTANCE IN TRICHOSTRONGYLES AT MANKON, N.W. PROVINCE OF CAMEROON

INTRODUCTION

It became apparent during the 1984-85 epidemiological study that treatment with 7.5 mg/kg body weight of fenbendazole was not resulting in a marked decrease in the average faecal egg count two weeks later (Table 26, showing this for a representative group). It was not possible to carry out critical anthelmintic trials because of the difficulty of obtaining animals in sufficient numbers for the studies in progress which meant that most of those that were available were on the long term epidemiological study. Accordingly, as a first step to rule out any possibility that this might have been a reflection of the short prepatent period of the trichostrongyles, strongyle egg counts were carried out on the animals of the 4-dose anthelmintic regime at the start of the second year's epidemiological study before and seven days after treatment.

Table 26 Strongyle egg counts from goats on monthly anthelmintic treatment with fenbendazole at Mankon, Cameroon, 1984/85.

Period	Median egg count	
	Pretreatment	Two weeks after treatment
December	50	4
January	50	4
February	30	4
March	0	0
April	4	22
May	50	125
June	50	375
July	325	450
August	950	125
September	350	200
October	300	250

The results were then compared with those obtained using levamisole (Nemicide, ICI) three months later, that is in early March. It was then decided to seek confirmation of this apparent benzimidazole resistance observed by

comparing the *in vitro* benzimidazole susceptibility of the strongyle-type eggs from the animals at Mankon with those obtained from village animals that had never been treated with anthelmintics.

EXPERIMENTAL DESIGN

Experiment 1 – Pre- and post-treatment strongyle egg counts

The study involved 20 sheep and 20 goats of the 4-dose anthelmintic regime in the second year epidemiological study. The animals were treated with fenbendazole 7.5 mg/kg body weight in the first week of December and later with levamisole 7.5 mg/kg body weight in the first week of March. Pretreatment egg counts were compared in each case with those made seven days after treatment.

Experiment 2 – Anthelmintic sensitivity test

The anthelmintics used for the study were commercial formulations of fenbendazole (Panacur, Hoechst) and tiabendazole (Merck, Sharp and Dohme, Haarlem, Netherlands). The range of concentrations tested were 0.05–100,000 ppm for fenbendazole and 0.05–20,000 ppm for tiabenzaole.

Trichostrongylid eggs were obtained from four sources namely Grassland Dwarf sheep and goats both at the research station and traditionally managed with village owners. It was assumed that trichostrongylid strains in the village animals would be fully susceptible as they had never been exposed to any anthelmintics.

Materials and methods: The degree of resistance by trichostrongyles in the animals to the benzimidazole anthelmintics was investigated by a modification of the anthelmintic sensitivity tests described by Le Jambre *et al.* (1976), Coles and Simpkin (1977) and Hall *et al.* (1978).

Fresh faeces were collected from each group of animals to be tested and the eggs extracted by macerating one or more 10g quantities of the faeces through a coffee strainer in ice-cold water. The number of 10g amounts used was determined by the strongyle-type egg count of the faeces, being enough to allow the recovery of at least 5,000–6,000 eggs. The washings were then quickly passed through successive sieves of pore sizes 150µ, 53µ and 38µ. The contents of each sieve were thoroughly washed with a hard jet of cold water. The contents from the 38µ sieve were collected and centrifuged for one minute at 1,000 rpm, the supernatant replaced with ice-cold saturated sodium chloride solution and the suspension recentrifuged at 1000 rpm for one minute. The eggs floating in the salt solution were recovered by again pouring them into a 38µ sieve and washing with cold

water. If necessary the flotation process was repeated to remove excess debris which remained when a large amount of faeces had been used initially. The eggs were finally washed out of the sieve with ice-cold water.

Table 27 Faecal egg counts from sheep and goats at Mankon, North West Province of Cameroon before and after treatment with 7.5 mg/kg fenbendazole and levamisole

Anthelmintic	Experimental group	Pretreatment egg count (epg)	Egg counts 7 days after treatment (epg)
Fenendazole (December)	4-dose sheep	258±419* (100)	126±267 (50)
	4-dose goats	82±85 (50)	263±273 (200)
Levamisole (March)	4-dose sheep	264±308 (150)	0 (0)
	4-dose goats	195±224 (125)	6±7 (0)

*Mean faecal egg count plus standard deviation with median count in brackets.

The egg suspension was then adjusted with ice-cold water to contain at least 300 eggs per ml, well mixed and dispensed into the wells (1.7 cm diameter x 2 cm deep) of a multi-well tray (Gibco NUNC), in 0.5 ml aliquots. A further 0.5 ml aliquot of the desired concentration of anthelmintic was added to each well and the tray incubated at 26°C for 24 hours.

Examination of the resulting eggs and/or larvae was carried out by transferring the suspended contents of each well into a McMaster slide, allowing the eggs or larvae to sediment, examining them under the low power (x10) of a compound microscope and counting unlarvated eggs, larvated eggs and hatched larvae separately. The percentage of eggs that had developed in each anthelmintic concentration was calculated as:-

$$\text{Percentage development} = \frac{\text{No. of hatched larvae + No. of larvated eggs}}{\text{No. of hatched larvae + Total No. of eggs}} \times 100$$

The percentage development was assessed against the development in a control without anthelmintic using the formula:-

$$\frac{\text{Percent development in test}}{\text{Percent development in control}} \times 100$$

These values were then plotted using probits and the concentrations giving

both 50 percent mortality (LC50) and 100 percent mortality (LC100) were estimated. The resistance factor, RF, was calculated from the formula:-

$$RF = \frac{\text{LC50 resistant strain}}{\text{LC50 susceptible strain}}$$

RESULTS

Experiment 1

The data on faecal egg counts before and after the treatments with fenbendazole and levamisole are shown in Table 27. The results indicate that treatment with fenbendazole at the beginning of the dry season did not significantly reduce the egg counts in both sheep and goats seven days later. However, following treatment with levamisole in early March, the faecal egg counts were reduced to zero in the sheep and almost so in the goats.

Experiment 2

The proportion of each species of egg in the faecal samples used for this study as deduced from larval cultures is shown in Table 28. The proportions varied widely but both *Haemonchus* and *Trichostrongylus* were present in all the samples while *Oesophagostomum* was more prevalent in the village animals.

Table 28 Proportion of each egg type in the faeces used as a source of eggs for the anthelmintic sensitivity test.

Source of faeces	Proportion of egg type in faeces (%)		
	Haemonchus	*Trichostrongylus*	*Oesophagostomum*
Mankon sheep	97.0	3.0	-
Mankon goats	42.0	52.6	5.3
Village sheep	32.4	34.6	33.0
Village goats	14.7	17.6	67.6

The log dose-probit (ld-p) lines drawn from the development percentages of each sample are shown in Figure 33 while the LC50 and LC100 are given in Table 29. Fenbendazole was insufficiently ovicidal and hatchability above 50% was observed at all concentrations and for all the sources of eggs, so only the results for tiabendazole are presented. A greater proportion of the

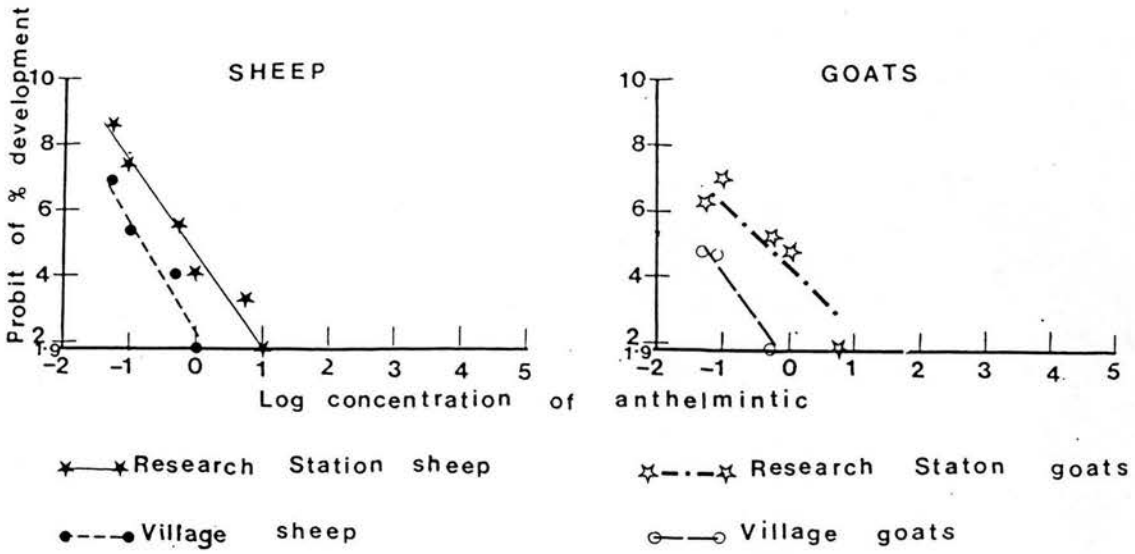


Figure 33 Dose response lines for tiabendazole against trichostrongyle eggs from mixed infections of sheep and goats under station and village management.

strongyle-type eggs from the animals at the research station consistently developed over the critical range of concentrations of tiabendazole than did the eggs from the village animals.

Table 29 Concentration of tiabendazole required to obtain 50 and 100 percent inhibition of embryonation of nematode eggs from mixed infections in sheep and goats

Source of eggs	Tiabendazole concentration	
	LC_{50}	LC_{100}
Mankon research station sheep	0.71	10.00
Village sheep	0.16	1.26
Degree of resistance*	4	8
Mankon research station goats	0.50	25.10
Village goats	0.06	0.56
Degree of resistance	8	45

*Research Station LC/Village LC

DISCUSSION

The results from faecal egg counts confirmed the suspicion of benzimidazole resistance by the trichostrongyles in the small ruminants at the research station, and this was further supported by the *in vitro* sensitivity test. In the latter study, it was found that the strains of trichostrongyles from neither of the sources showed *in vitro* susceptibility to fenbendazole. Hall *et al.* (1978) also found that fenbendazole is only active *in vitro* at high concentrations. The concentration of tiabendazole which killed 50 percent of the larvae in the village sheep was very similar to that reported for *H. contortus* and *Trichostrongylus* by Coles and Simpkin (1977). Similarly the level necessary to kill 50 percent of the larvae in the eggs from the sheep at the research station was similar to that for known resistant strains reported by Hall *et al.* (1978). The results suggested that the parasites at Mankon were indeed less susceptible to this drug than those in the village animals. Larval culture on the faeces of both groups of animals showed that the species distribution of strongyle parasites differed markedly with *Oesophagostomum* being much more prevalent in the village animals. However this does not entirely confound the results since, even if the *Oesophagostomum* eggs are particularly susceptible to the anthelmintic, this cannot account for the 4-8 fold difference in the concentration which inhibited development in 50 percent

of the eggs (LC50) or the 8-45 fold difference in that which inhibited all development (LC100). It therefore seemed reasonable to conclude that the trichostrongyle parasites in the sheep and goats at Mankon have become benzimidazole resistant. The decision to change anthelmintic resulted but could not be operative for experimental and logistic reasons until the second treatment of the second year epidemiological study.

EPIDEMIOLOGICAL STUDY 1985-1986

INTRODUCTION

The results of the 1984-85 epidemiological study showed that even with a relatively ineffective anthelmintic, a strategic anthelmintic regime involving 4-5 doses of the anthelmintic produced similar results as a regime involving monthly dosing. This suggested that the use of a more effective anthelmintic would require even fewer doses to produce similar results. Thus, two reduced anthelmintic regimes, a 4-dose and a 2-dose, were compared during the 1985-86 epidemiological study.

Two other experiments, one involving mixed grazing of sheep and goats, and the other, an attempt to simulate traditional management on-station, provided an opportunity for a closer and more objective evaluation of the differences between sheep and goats in their responses to helminth infections when subjected to the same environmental pressure under research station and traditional management conditions respectively.

The parameters measured were the same as in the 1984-85 study except that in the haematology only PCV was measured. This was because the previous year's study had shown a positive correlation between PCV and Hb concentration thus implying that either parameter could serve as a sensitive indicator of the degree of anaemia.

EXPERIMENTAL DESIGN

There were five treatment groups for both sheep and goats. These were:-

(a) **Four dose anthelmintic:** A regime which was similar to the reduced anthelmintic regime of the previous year except that fenbendazole at 7.5 mg/kg body weight was given only in the first week of December and was then replaced by levamisole (Nemicide, ICI) at 7.5 mg/kg body weight for the subsequent treatments in the first weeks of March, July and September.

(b) **Two dose anthelmintic:** A regime in which the animals were given levamisole at 7.5 mg/kg body weight only twice in the year, in the first week of May and last week of July.

(c) **Mixed grazing:** A regime in which the sheep and goats were housed together and grazed on the same pasture. They were treated with levamisole at 7.5 mg/kg body weight in the first week of May and last week of July.

(d) **On-station traditional:** An attempt to replicate at Mankon the management method used in the village where sheep and goats were kept together in a flock with little supplementary feeding in the dry season and no

anthelmintic treatment. As far as possible the six ewes and six does in the on-station traditional management study were managed in the same way as the village animals. Between September and February, the non-cropping season, the animals were kept on a modified "free range", only restricted within a one hectare paddock. They were tethered in the cropping season between March and August.

(e) **Village traditional:** The management system used in the village was the same as in the previous year's study except that two of the three cooperating farmers tethered their animals throughout the year. Other details for these animals are shown in Table 30.

The animals in the 4-dose and 2-dose anthelmintic groups as well as those on mixed grazing and on-station "traditional" management were kept at the research station in Mankon while the traditionally managed group was with three of the farmers at Batibo who cooperated in the previous year's study.

The two groups of 20 sheep and 20 goats on the 2-dose anthelmintic regime were set-stocked on the paddocks previously grazed by the animals on the standard regime while the two groups of 20 sheep and 20 goats on the 4-dose anthelmintic regime were set-stocked on the paddocks previously grazed by the animals on the reduced regime. The two small paddocks for each experimental group of goats were converted into a single paddock by opening a gap between them. The ten sheep and ten goats on mixed grazing were set-stocked on a half hectare paddock of unimproved pasture.

The parameters measured included liveweight changes, faecal egg counts, larval cultures and differentiation all determined monthly. Packed cell volume and serum biochemistry (total protein, albumin and globulin) were measured only on the animals at the research station from blood samples collected in the first weeks of December, March, June, September and December.

The study lasted from December 1985 to December 1986.

RESULTS

Meteorological data

The temperature and rainfall data for 1985-86 are summarised in Figure 34. The seasonal pattern was very similar to that in 1984-85 (Figure 3). There was little or no rain between December and mid-March. Rain fell from about mid-March until mid-November with a peak in August when 445 mm of rainfall was recorded as against 339 mm recorded in 1984-85. After August the rainfall decreased rapidly to dry season low levels in November.

Table 30 Age and sex distribution of experimental sheep and goats under five management systems in the North West Province of Cameroon

Site	Management group	Sheep				Goats			
		Rams	Ewes	Yearlings	Lambs	Bucks	Does	Yearlings	Kids
	group 4-dose	4	6	4	6	3	8	5	4
	2-dose	4	6	4	6	3	8	5	4
Mankon	Mixed grazing	1	9	0	0	1	9	0	0
	On-station traditional	0	6	0	0	0	6	0	0
	Traditional	1	7	1	3	0	6	2	2
Batibo	A	0	0	0	0	0	2	1	2
	B	0	3	0	1	0	1	0	0
	D	1	4	1	2	0	3	1	0

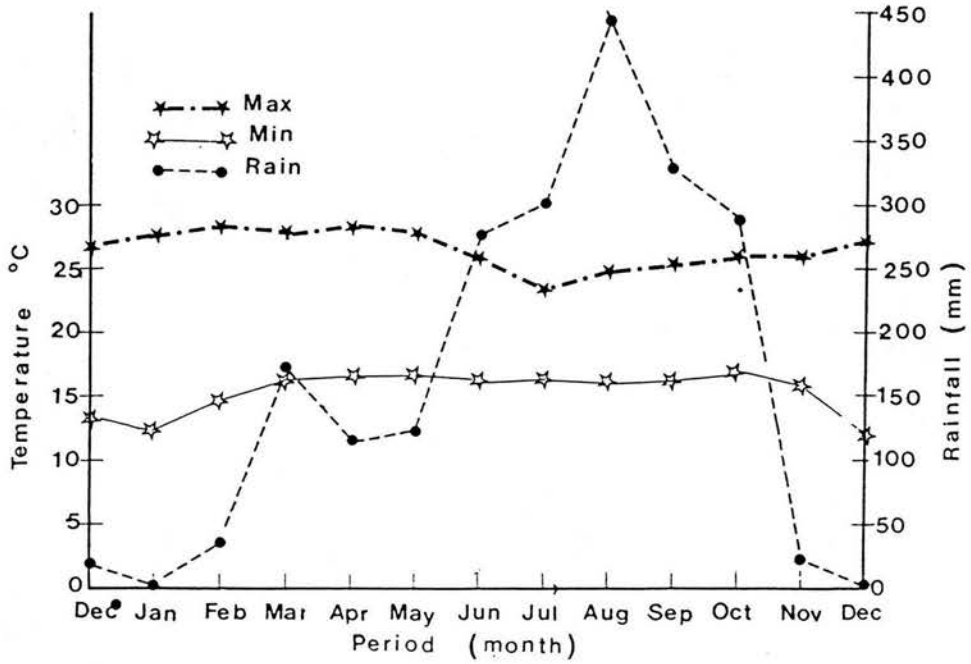


Figure 34 Meteorological data for Mankon 1985-86.
Mean monthly maximum temperature
Mean monthly minimum temperature
Total monthly rainfall.

The mean monthly minimum temperature was above 15°C except between December and February, again as in 1984-85. The lowest maximum temperatures of 24.0 and 23.5°C were recorded in July of 1985 and 1986 respectively.

Productivity

Table 31 Mortality in sheep and goats kept under different management systems in the N.W. Province of Cameroon

Management system	Animals that died/animals in group (percentage mortality)	
	Sheep	Goats
4-dose anthelmintic regime	2/20 (10%)	9/20 (45%)
2-dose anthelmintic regime	1/20 (5%)	11/20 (55%)
Mixed grazing	1/10 (10%)	4/10 (40%)
Village traditional management	9/12 (75%)	4/8 (50%)
On-station traditional management		
1/12/85-1/9/86	4/6 (67%)	2/6 (17%)
1/12/85-1/12/86	4/6 (67%)	5/6 (83%)
Improved management	4/50 (8%)	24/50 (48%)
Traditional management	13/18 (72%)	9/14 (64%)

The survival rate (Table 31) was significantly higher in sheep than in goats on both the 4-dose ($P < 0.05$) and 2-dose ($P > 0.01$) anthelmintic regimes. In the group on mixed grazing, even though four goats died as against only one sheep, the difference was not significant. Overall the traditionally managed goats again survived better than sheep under village conditions and also in the on-station trials until September but there were a number of deaths in this group at Mankon. Post-mortem examination of the three goats on the on-station traditional management that died between September and December revealed heavy worm burdens of *H. contortus*, *T. colubriformis* and *O. columbianum* (Appendix 10) suggesting death from parasitic gastroenteritis. A higher mortality rate was recorded in village goats in 1985/86 (50%) than in 1984/85 (6%). All the deaths occurred in the flocks of the two farmers who tethered their animals throughout the year.

The liveweight changes in different classes of animals under different management systems are shown in Table 32 and Appendix 5. At Mankon there

Table 32 Mean initial liveweight and mean weight gains in sheep and goats in the N.W. Province of Cameroon 1985-86

Type of animal	Sex/Age	Type of management	No. of animals	Initial liveweight (kgs)	Liveweight gain (kg) Dec.-Nov.
Sheep	Lambs	4-D	6	10.9	7.4
		2-D	6	11.6	7.5
	Female yearlings	4-D	4	18.4	0.4
		2-D	4	19.8	0.5
	Ewes	4 -D	5	24.0	-0.8
		2-D	5	25.2	-4.1
		Mx	8	17.9	-0.03
		TS	2	27.1	-8.5
		TVM	2	16.0	-1.1
	Rams	4-D	3	29.1	3.3
		2-D	4	30.1	2.5
		Mx	1	26.0	7.5
		TVM	1	17.3	5.1
	Kids	4-D	1*	9.5	1.0
		TVM	2**	9.4	7.8
Goats	Female yearlings	4-D	3	12.1	2.8
		2-D	2	12.3	5.5
	Does	4-D	5	15.7	4.2
		2-D	6	15.5	3.3
		Mx	6	15.7	4.0
		TS	1	19.0	-3.5
		TVM	3	22.0	-1.3
	Bucks	4-D	2	14.4	5.4
		2-D	1	12.0	7.5

*All kids on the 4-dose and 2-dose anthelmintic regimes except one died before the end of the study.

**Mean initial weight at the beginning of January - Other initial weight at the beginning of December.

4-D = 4-dose anthelmintic; 2-D = 2-dose anthelmintic;
Mx = Mixed grazing; TS = On-station traditional management
TVM = Traditional village management

were no significant differences in liveweight gains between sheep on the 4-dose and 2-dose anthelmintic regimes even though the ewes on the latter regime lost more weight than those on the former. Similarly, the 2-dose regime gave similar results with goats to the 4-dose regime. Does gained weight whereas ewes had lost weight and this difference was significant ($P < 0.005$). Yearling sheep also gained less weight than yearling goats but the difference was not significant. The surviving animals on the 4-dose anthelmintic regime put on more total liveweight than the surviving ones on the 2-dose regime (Table 33), the difference being significant in sheep ($P < 0.05$).

Table 33 Total liveweight gains of surviving animals under different management systems at Mankon Research Station

Management system	Sheep			Goats		
	Initial total liveweight (kg)	Final liveweight (kg)	Total liveweight gain (kg) Dec.-Nov.	Initial total liveweight (kg)	Final liveweight (kg)	Total liveweight gain (kg) Dec.-Nov.
4-dose regime	346.2	398.7	52.5	152.7	193.7	41.0
2-dose regime	395.0	432.0	37.0	129.5	167.5	38.0
Mixed grazing	169.5	176.7	7.2	89.0	118.0	29.0

Village sheep and goats also lost weight, especially the ewes and does. The on-station attempt to replicate traditional management gave a similar picture with the weight loss being greater in ewes than in does.

In the sheep and goats on mixed grazing, the does gained significantly ($P < 0.01$) more weight than the ewes.

Table 34 Reproductive performance of sheep and goats under two management systems at Mankon Research Station

Parameters observed	Sheep		Goats	
	2-dose	4-dose	2-dose	4-dose
Number of females	9	9	10	11
Number pregnant	8	9	5	3
Number of young born	12	17	7	3
Fertility (%)	89	100	50	27
Prolificacy (%)	150	189	140	100
Lambing/kidding rate (%)	133	189	70	27
Reproductive rate (young/female/year)	1.5	1.9	1.4	1.0

Data on reproductive performance of the sheep and goats on 4-dose and 2-dose anthelmintic regimes are presented in Table 34. The lambing rate was greater than the kidding rate with 29 lambs born as against only 10 kids. There were no multiple births but a lambing/kidding interval of 199-205 days allowed for the possibility of two lambings/kiddings per year. Approximately half the lambings took place between September and November and resulted in significant weight losses in the lambing ewes. Mating was observed at a greater frequency between November and December and this coincided with a period of weight losses in the rams. On the other hand, no kidding occurred after May and most of the does were observed to be heavily pregnant by the time the experiment ended in early December.

Faecal egg count

The data on faecal egg counts is shown in Figures 35-40 and Appendix 5. Between December and February egg counts generally remained low (< 500 epg) regardless of whether treatment had been given early in the dry season. Following anthelmintic treatment in the 4-dose groups with levamisole in early March, the faecal egg counts were initially reduced to zero in both sheep and goats. In the goats the counts then remained below 200 epg throughout the rainy season. In sheep, however, there was a rise in April with the onset of the rains but the counts fell again after the June treatment, then remaining below 200 epg throughout the rest of the study.

In the groups on 2-dose anthelmintic (Figures 35-37) where the first anthelmintic treatment was given only at the beginning of May, the faecal eggs counts during the dry season were somewhat higher than in the 4-dose groups. Lambs and kids had higher counts than yearlings and adults, the difference being significant ($P < 0.05$) in the sheep between November and February. In the sheep, egg counts fell progressively from mid dry season and by May, they were only 200 epg. Anthelmintic treatments given in May and July maintained the egg count at this low level throughout the rainy season. In goats there was a significant ($P < 0.01$) increase in egg count at the beginning of the rainy season with a peak at the end of March. The counts fell without treatment in April and were then maintained at a low level throughout the rainy season by the anthelmintic treatments given in May and July,

The sheep and goats on mixed grazing (Figure 38) had not grazed together prior to the trial commencing. The sheep had an initial faecal egg count which was higher than that of the goats but the difference between

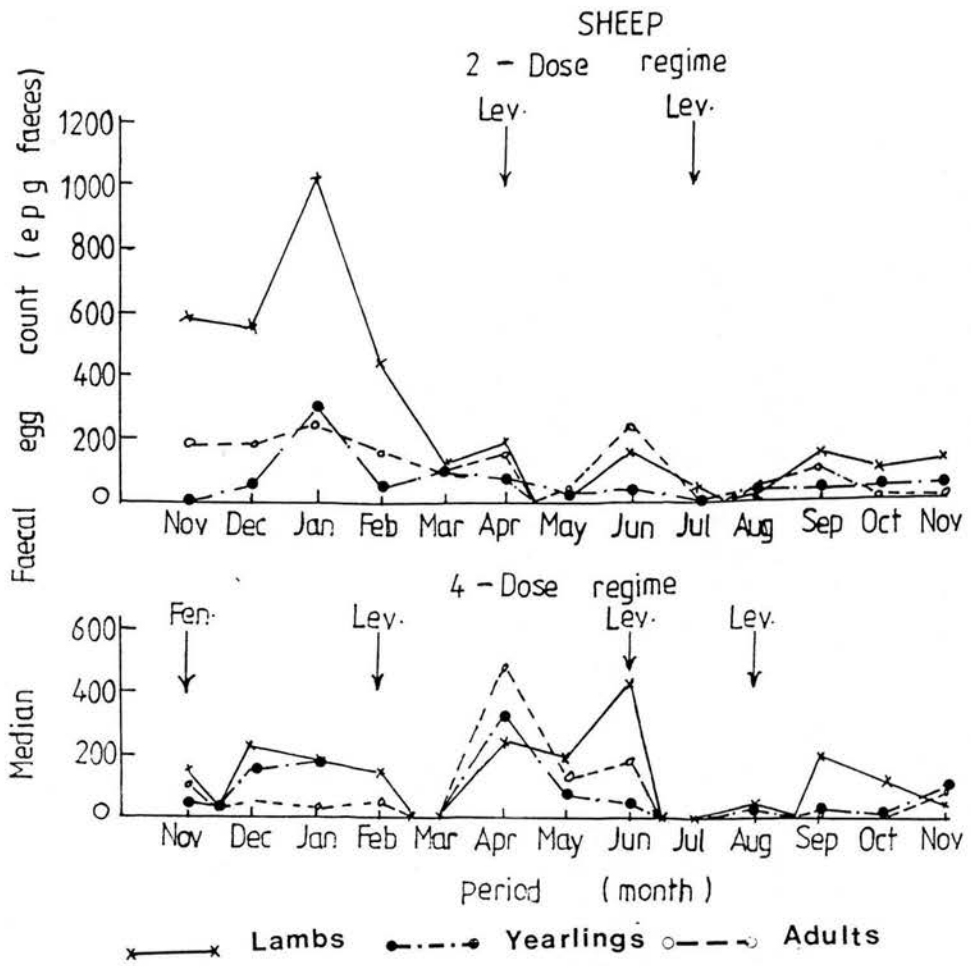


Figure 35 Median faecal egg counts of sheep under 2-dose and 4-dose anthelmintic regimes at Mankon (Nov. 1985-Nov. 1986).

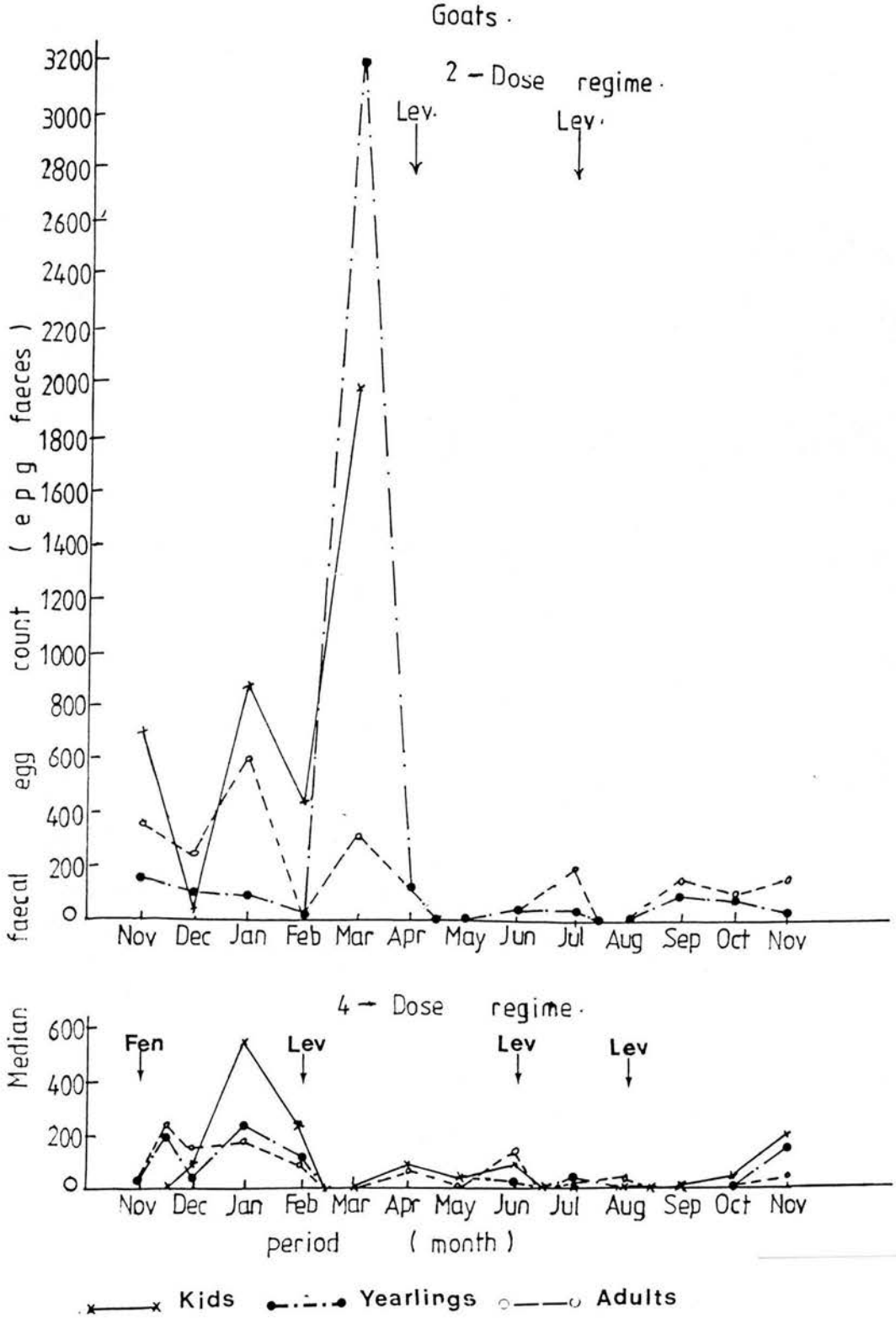


Figure 36 Median faecal egg counts of goats under 2-dose and 4-dose anthelmintic regimes at Mankon (Nov. 1985-Nov. 1986).

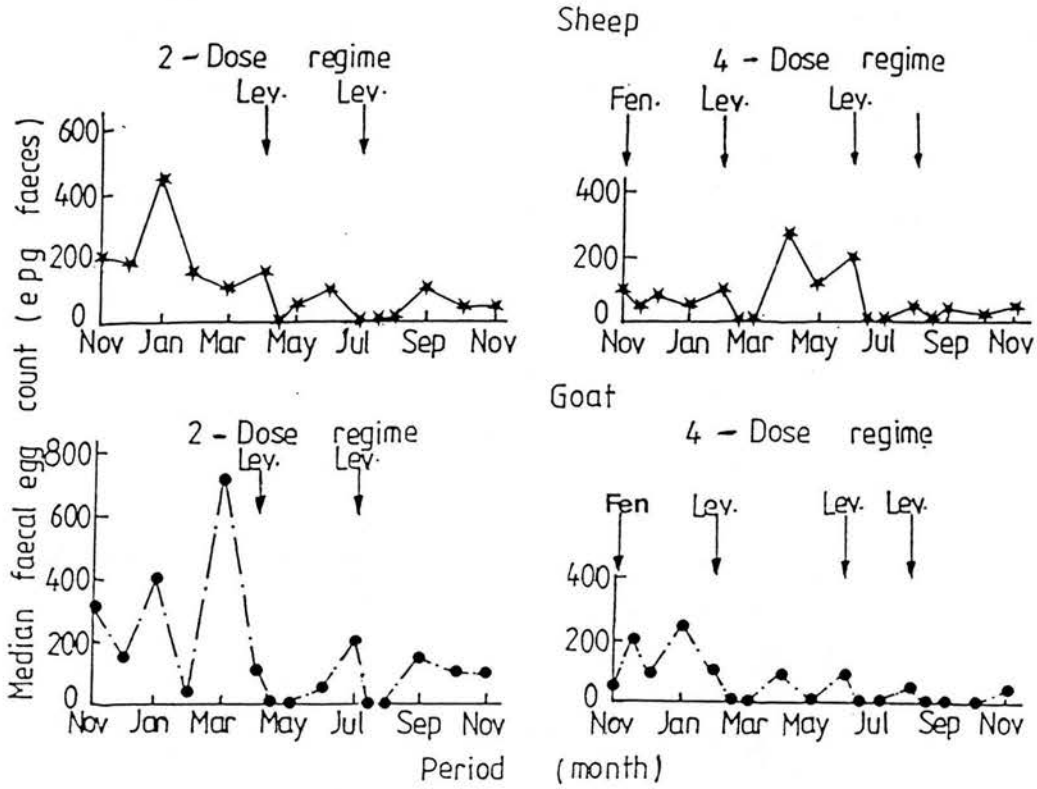


Figure 37 Median faecal egg counts of sheep and goats under 2-dose and 4-dose anthelmintic regimes at Mankon (Nov. 1985-Nov. 1986).

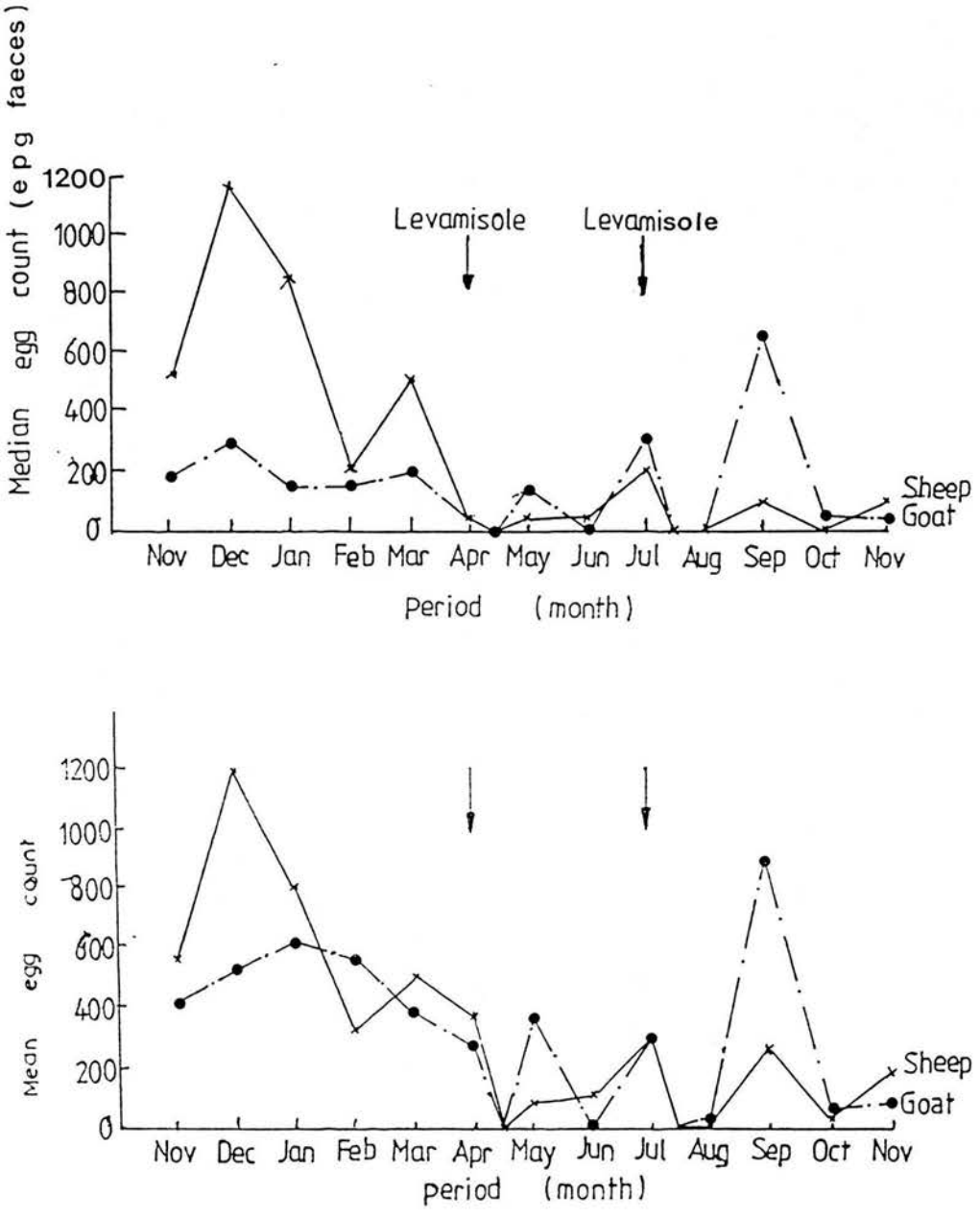


Figure 38 Median and mean egg counts of adult sheep and goats on mixed grazing (Nov. 1985-Nov. 1986).

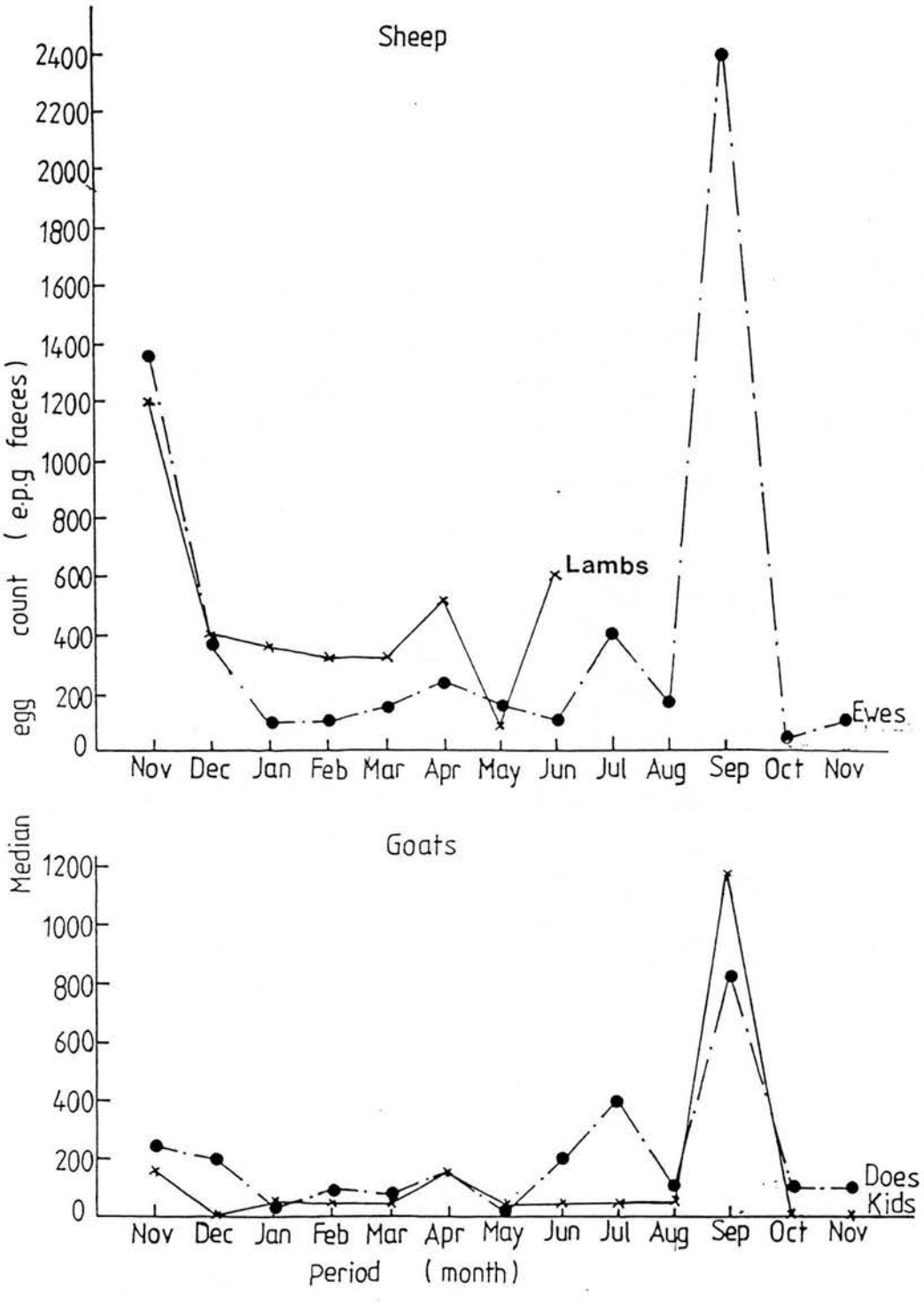


Figure 39 Median faecal egg counts of sheep and goats under traditional village management (Nov. 1985-Nov. 1986).

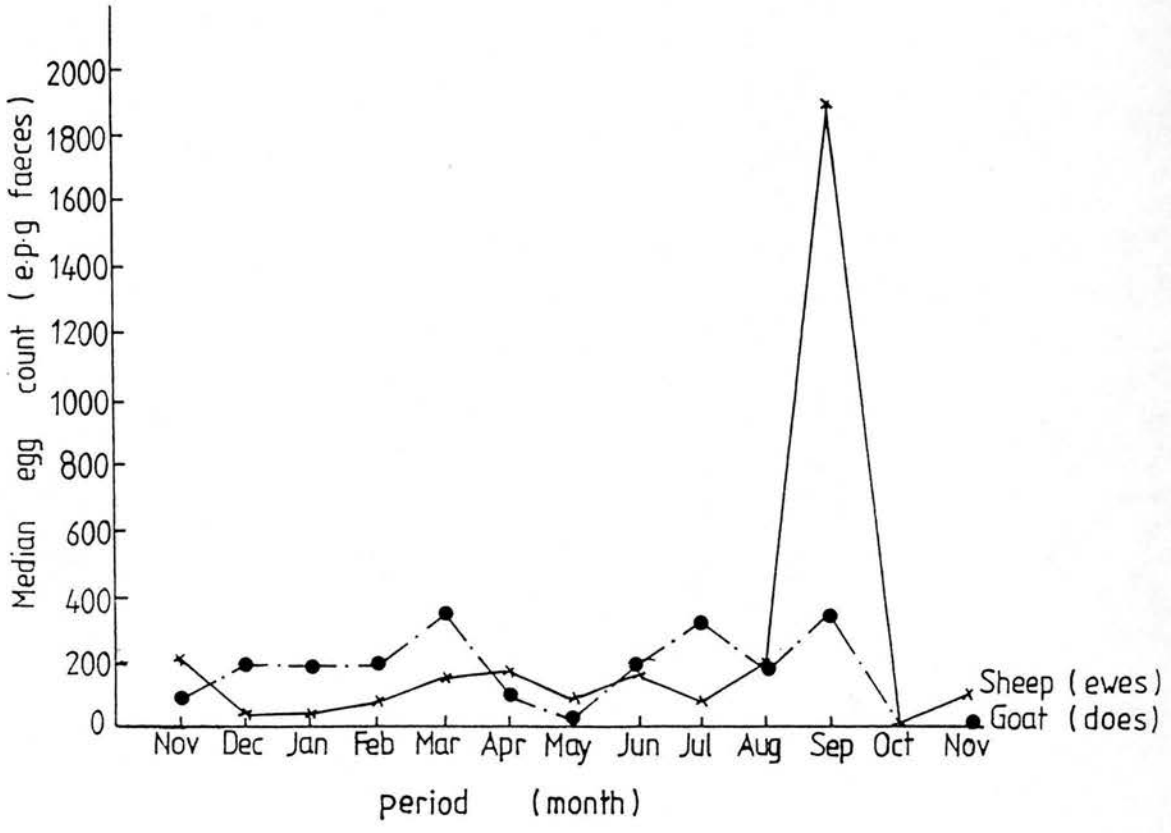


Figure 40 Median faecal egg counts of sheep and goats under on-station traditional management (Nov. 1985-Nov. 1986).

their egg counts gradually decreased as the dry season progressed. After levamisole treatment at the beginning of May, the egg counts in the sheep remained at a lower level than in goats almost throughout the remaining study period, the difference being particularly evident in September. However, even though the median counts in that month were 100 and 650 epg in sheep and goats respectively, this difference was not significant.

The faecal egg counts in sheep and goats under village and on-station traditional managements are presented in Figures 39 and 40. Egg counts decreased in all the animals at the beginning of the dry season in December and remained low (< 400 epg) until August. Peak counts in both groups of animals were obtained in September (not really in goats on-station) with the peak levels being much higher in sheep than in goats but the difference was not significant. They fell in all animals in October to the dry season low levels of < 100 epg.

Larval cultures and differentiation

The results of the larval cultures with faeces from the 4-dose and 2-dose anthelmintic regimes are summarised in Table 35. In general a higher proportion of *Haemonchus* eggs were present in sheep than in goat faeces. On the other hand, *Oesophagostomum* eggs were present in a higher proportion in goat than in sheep faeces. However none of these differences were significant. *Trichostrongylus* appeared to be present in a similar proportion in both species. Whereas *Haemonchus* and *Trichostrongylus* were observed at all the four sampling times, *Oesophagostomum* was not observed in any of the March cultures. The proportion of *Oesophagostomum* eggs increased more or less consistently as the rainy season advanced to reach the highest levels at the end of the rains. There were no significant differences in the prevalence of any of the nematode species type under the two management systems.

Herbage larval counts and differentiation

The patterns of the infective larval contamination of the sheep and goat pastures under the 2-dose and 4-dose anthelmintic regimes are shown in Figure 41. Under both management regimes, the numbers of infective larvae on the pasture decreased at the onset of the dry season and remained low until April. The counts rose rapidly at the onset of the rains to give rise to a biphasic pattern during the rains with a low point in mid-July. The larval contamination of the goat pastures was heavier than that for the sheep pastures, with peak levels being considerably higher on goat than on sheep

Table 35 Prevalence of infective larvae from larval cultures of sheep and goat faeces

Experimental group	Date of sample	Prevalence of infective larvae in faeces (%)					
		Sheep			Goats		
		H. cont.	Tricho.	Oes.	H. cont.	Tricho.	Oes.
2-dose anthelmintic regime	4/3/86	62.00	38.00	0	66.00	34.00	0
	1/6/86	88.00	12.00	0	95.00	5.00	0
	4/9/86	97.00	2.75	0.25	70.60	26.70	2.70
	1/12/86	65.75	28.00	6.25	15.33	51.67	33.00
4-dose anthelmintic regime	4/3/86	63.00	37.00	0	59.00	41.00	0
	1/6/86	59.00	35.00	6.00	89.00	9.00	2.00
	4/9/86	65.75	30.00	4.25	62.75	30.00	7.25
	1/12/86	76.25	12.00	11.75	50.75	33.25	16.00
Mean:	2-dose	78.19±17	20.19±15.81	1.63±3.09	61.73±33.45	29.34±19.32	8.93±16.10
	4-dose	66.0±7.37	28.5±11.39	5.5±4.87	65.38±16.53	28.31±13.68	6.31±7.15
All animals		72.09±13.77	24.34±13.50	3.56±4.30	63.55±24.50	28.83±15.51	7.62±11.62

H. cont. = H. contortus; Tricho. = Trichostrongylus; Oes. = Oesophagostomum

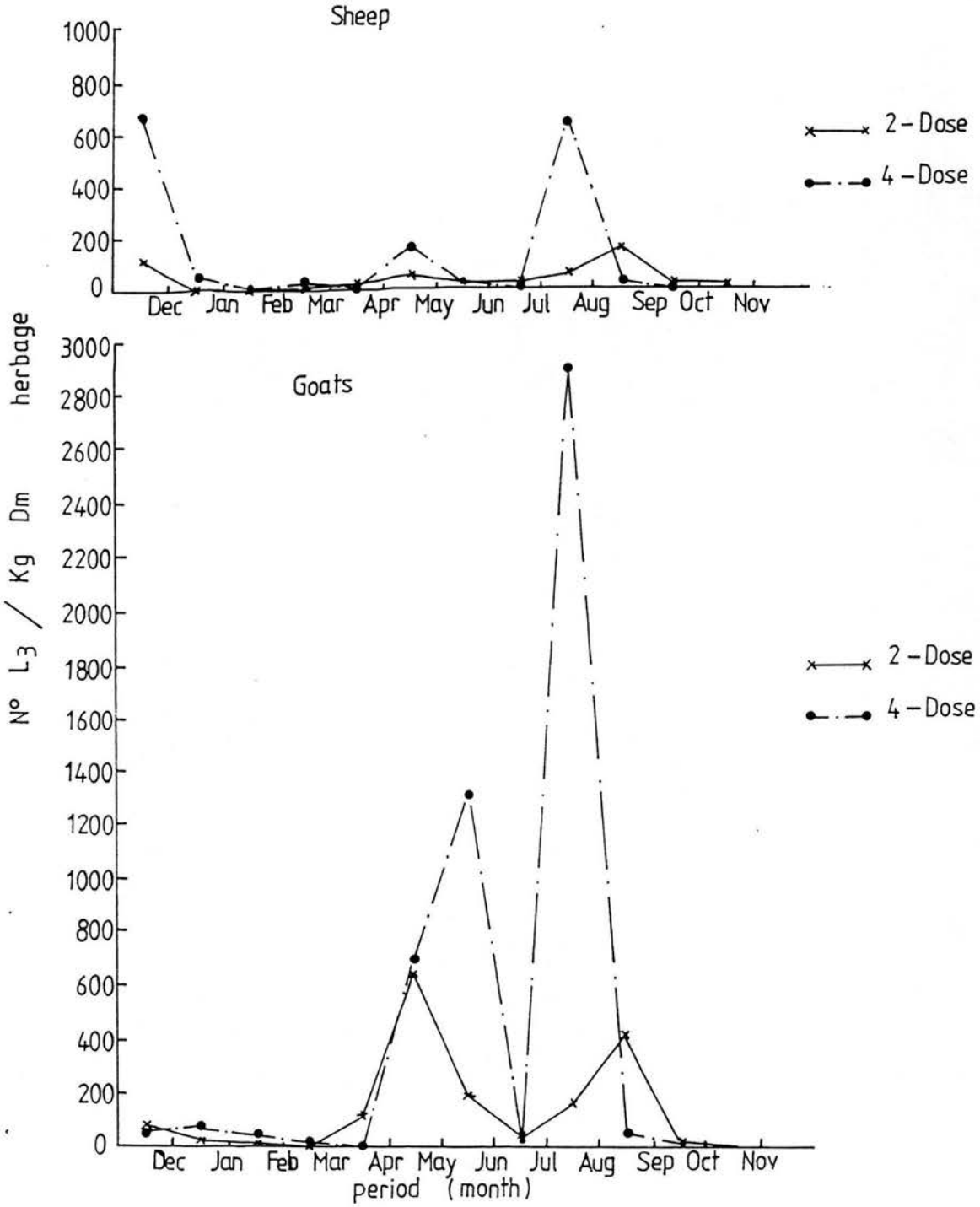


Figure 41 Pasture larval counts from IRZ, Mankon pastures (Dec. 1985-Nov. 1986).

pastures.

On the pastures of the traditionally managed sheep and goats (Figure 42), two peaks were again evident, a higher peak (2770 L_3/kg DM) at the end of May and a lower one (282 L_3/kg DM) at the end of September. The larval counts on the pastures grazed by sheep and goats on mixed grazing at the research station (Figure 42) were low throughout (< 200 L_3/kg DM). It is worth noting that these pastures had not been grazed in the previous year.

The counts and species recovered from the pastures are shown in Appendix 6-9. *Haemonchus contortus* was the most prevalent species throughout the rainy season. *Trichostrongylus* spp. and *Oesophagostomum columbianum* were recovered mostly in the early rains between April and June and in the latter part of the rainy season. The results indicate that most pastures remained contaminated throughout the year although the very low levels of larvae recovered during the dry season depict that the infection rate was minimal during this period.

Necropsy of experimental animals

The results of the post-mortem examinations on the animals that died during the study are presented in Appendix 10. Other species recovered included adults of *Paramphistomum microbothrium* from the rumen and reticulum and *Cysticercus tenuicollis* (the larval form of *Taenia hydatigena*) from the peritoneum.

The results show that *H. contortus*, *T. axei*, *T. colubriformis* and, to a lesser extent, *M. expansa* were prevalent throughout the year. The summary data for necropsies in sheep (Table 36) and goats (Table 37) reveal that there were comparatively lower counts of *H. contortus* and higher counts of *B. trigonocephalum* and *O. columbianum* in the sheep than in the goats that died except in the early dry season when *H. contortus* counts were higher in sheep. The data on goats (Table 37) shows that larger numbers of *H. contortus* were present in animals that died during the rainy season than in those that died during the dry season. The highest counts of this species were obtained in April, June and September. The pattern for *T. colubriformis* was similar to that of *Haemonchus* but high counts of this worm were obtained in January as well. As in the previous year, the highest *H. contortus* burden of 8650 adult worms from a single animal at autopsy was from a goat as against a maximum count of only 1910 from a sheep.

Relatively high counts of *B. trigonocephalum* were obtained in occasional animals in January and at various times during the rainy season,

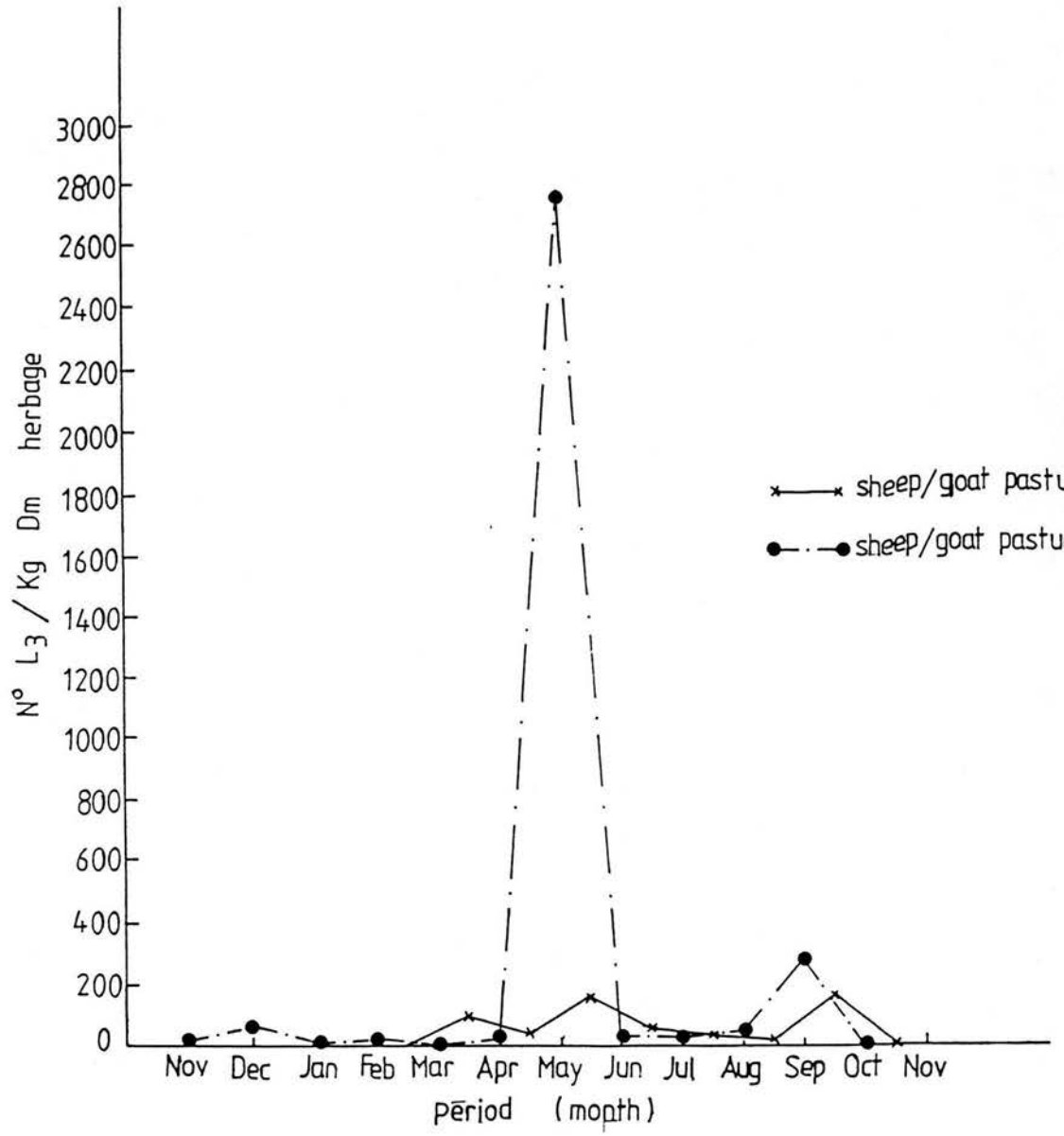


Figure 42 Pasture larval counts from pastures jointly grazed by sheep and goats (Nov. 1985-Nov. 1986).

Table 36 Post-mortem worm counts in sheep in N.W. Province of Cameroon 1985/86

Period (month)	No. of sheep examined	Mean number of worms per infected animal								
		H. cont.	T. axei	T. colubr.	B. trigo.	S. papill.	O. columb.	Trichu. ovis	M. expansa	Meta-cestodes
December	1	770	800	3500	50	-	820	-	-	-
January	9	912	325	12272	154	-	279	1	2	+
February	1	200	-	-	-	-	-	-	-	-
May	2	100	-	925	70	-	245	-	-	-
July	1	190	500	7100	210	-	9	-	-	-
October	1	110	-	21000	-	-	267	57	-	+

H. cont. = H. contortus; T. colubr. = T. colubriformis; B. trigo. = B. trigonocephalum; S. papill. = S. papillosus; O. columb. = O. columbianum; Trichu. ovis = Trichuris ovis

Table 37 Post-mortem worm counts in goats in N.W. Province of Cameroon 1985/86

Period (month)	No. of goats examined	Mean number of worms per infected animal								
		H. cont.	T. axei	T. colubr.	B. trigo.	S. papill.	O. columb.	Trichu. ovis	M. expansa	Meta-cestodes
December	1	80	50	950	10	-	3	-	-	-
January	6	702	127	7283	-	-	-	-	1	+
February	2	870	-	1850	-	-	-	-	-	-
March	4	1193	33	8433	-	-	-	-	1	-
April	5	1540	150	2360	-	-	-	-	-	+
May	2	575	-	625	-	-	-	-	2	-
June	5	2112	290	7140	-	20	51	3	2	-
July	3	547	250	917	3	-	12	21	1	+
August	-	-	-	-	-	-	-	-	-	-
September	1	8650	-	6550	-	-	93	-	-	-
October	2	5145	50	12250	-	-	92	2	2	+
November	1	550	-	250	-	-	5	-	-	-

H. cont. = H. contortus; T. colubr. = T. colubriformis; B. trigo. = B. trigonocephalum; S. papill. = S. papillosus; O. columb. = O. columbianum; Trichu. ovis = Trichuris ovis

especially from May whereas *O. columbianum* was particularly common in the latter part of the rains and early in the dry season. *T. ovis* was recovered in increasing numbers only during the wet season.

Most of the higher *Haemonchus* counts (.i.e. > 1000 worms) were from sheep and goats under traditional management and goats on the 2-dose anthelmintic regime. *Oestrus ovis* larval infestation was a particular nuisance in the goat flocks as evident from the high counts of larvae at necropsy. Tick infestation was an additional problem in village flocks at the onset of the rainy season as assessed visually from the large numbers on the animals at this period compared to the dry season.

Haematology

The PCV changes in sheep and goats on the four management regimes at the research station are shown in Figures 43 and 44 and Appendix 5. In most groups the lowest values were recorded in February and the highest in August or November. In several cases including both groups on mixed grazing, both the 2-dose and 4-dose regimes, the differences were significant. The PCV values in the goats on 2-dose and 4-dose anthelmintic regimes were significantly higher ($P < 0.001$) in November than in February. Similarly in the animals on mixed grazing, the values recorded in August were significantly higher than those recorded in February (sheep: $P < 0.001$, goats: $P < 0.01$).

The PCV values in the goats under on-station traditional management were much lower than those recorded in the other animals at the research station including the on-station traditional sheep with the lowest values of 17 percent recorded in February.

Serum biochemistry

The results of the serum protein and serum protein fraction studies are presented in Figures 45-48 and Appendix 5. There were significant seasonal variations in animals under different management systems. In sheep under the 2-dose and 4-dose anthelmintic regimes (Figures 45 and 47) the values varied in a similar way in the two groups, remaining low until May but thereafter, the total protein and globulin concentrations increased consistently and significantly ($P < 0.001$) for both parameters and both groups. The animals on the 4-dose anthelmintic regime maintained slightly higher total protein and albumin values during the wet months than those on the 2-dose anthelmintic regime (Figure 47). By contrast the globulin values were slightly higher in the animals on the 2-dose regime throughout most of the year. There was no significant difference in response between the different classes of animals

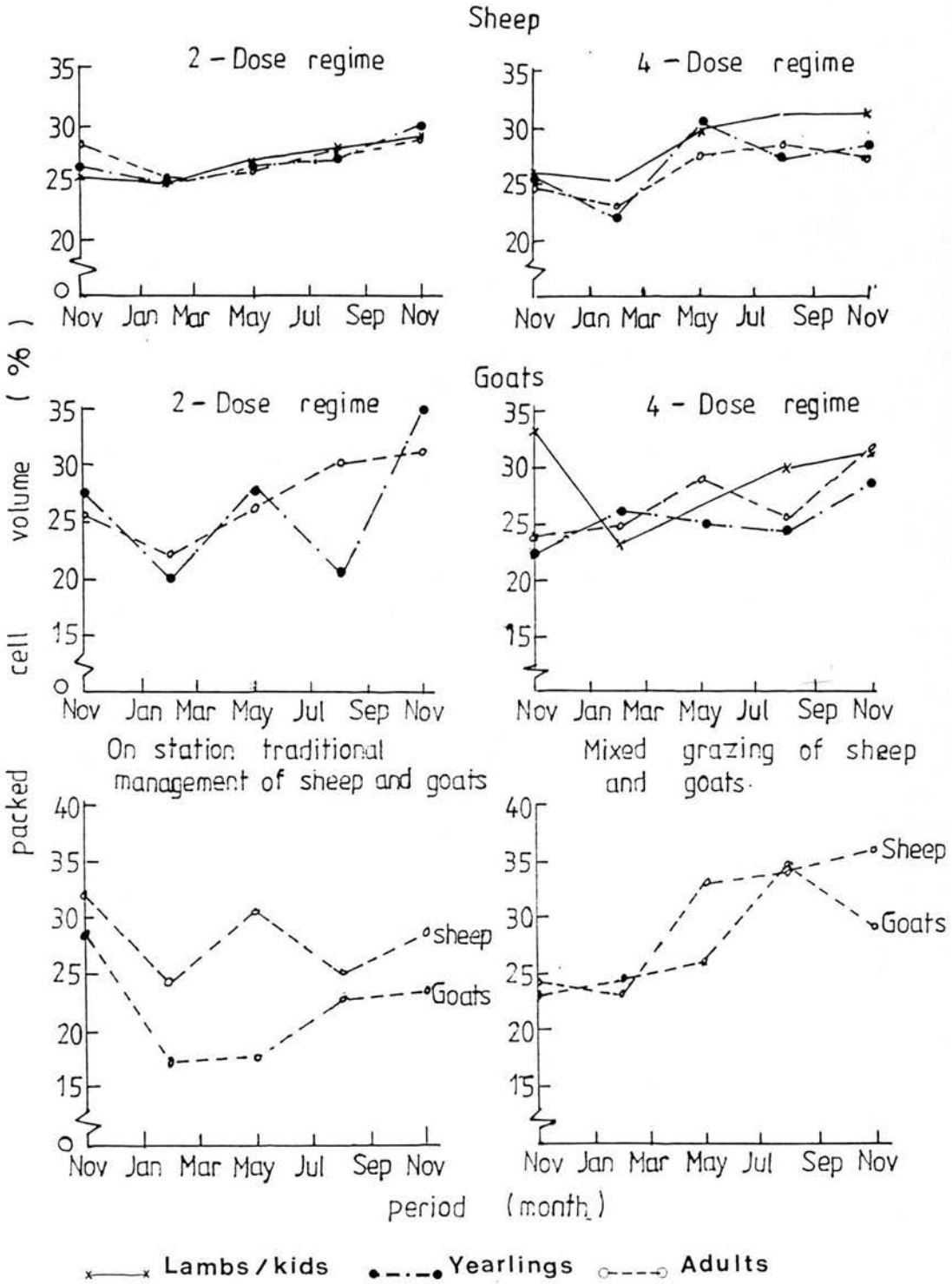


Figure 43 Packed cell volume changes in sheep and goats (young, yearling, adults) under different management systems at Mankon, Cameroon.

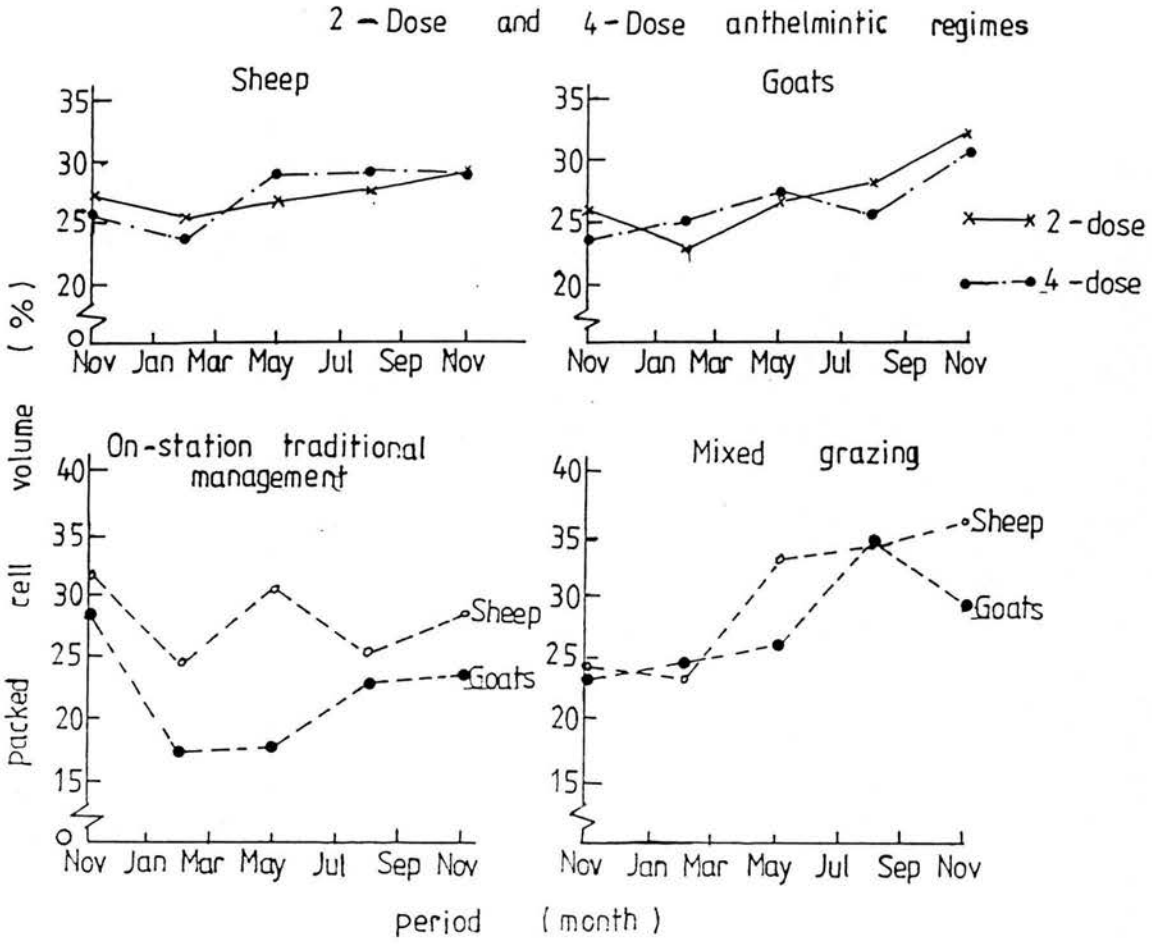


Figure 44 Packed cell volume changes in sheep and goats under different management systems at Mankon, Cameroon.

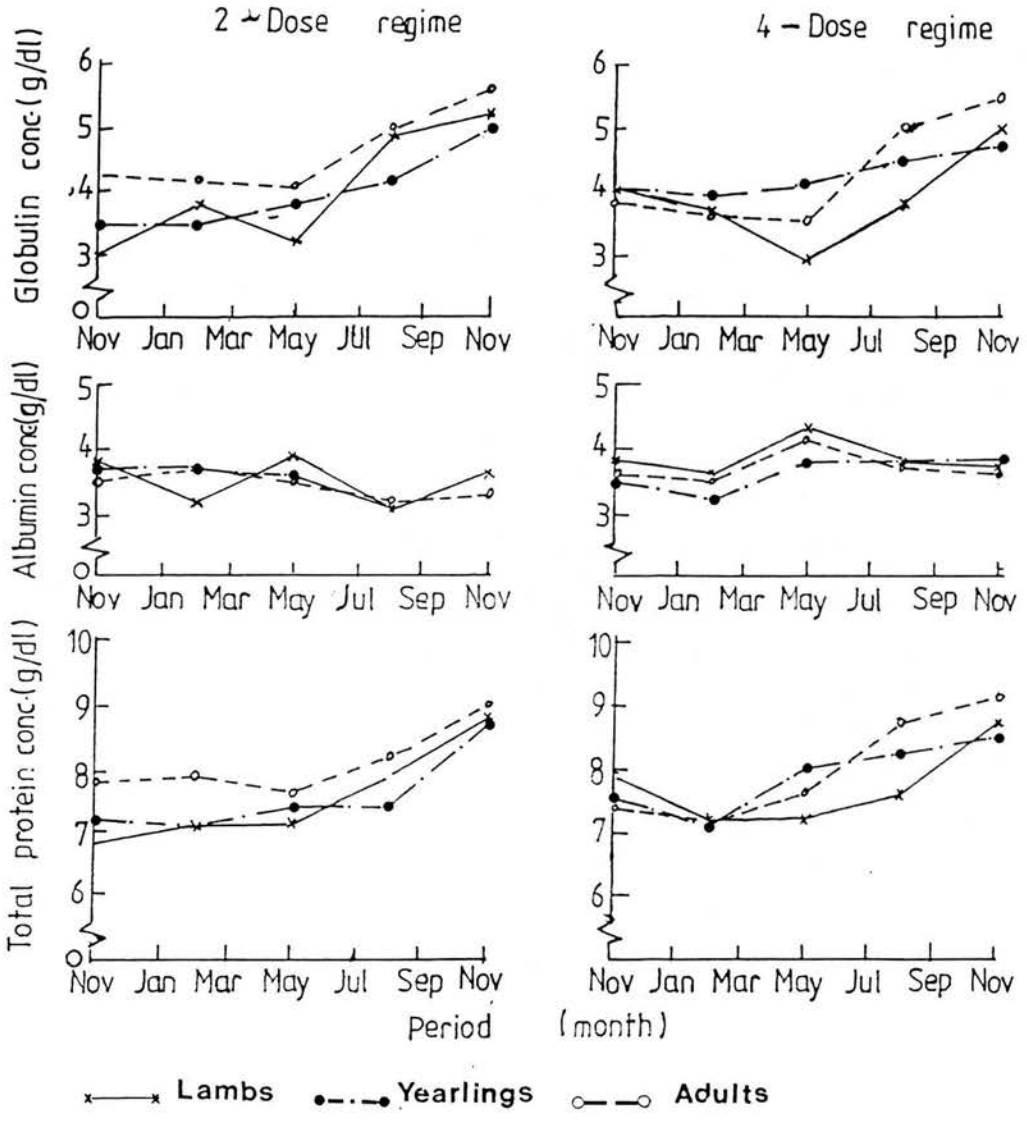


Figure 45 Serum protein changes in sheep under 2-dose and 4-dose anthelmintic regimes at Mankon, Cameroon.

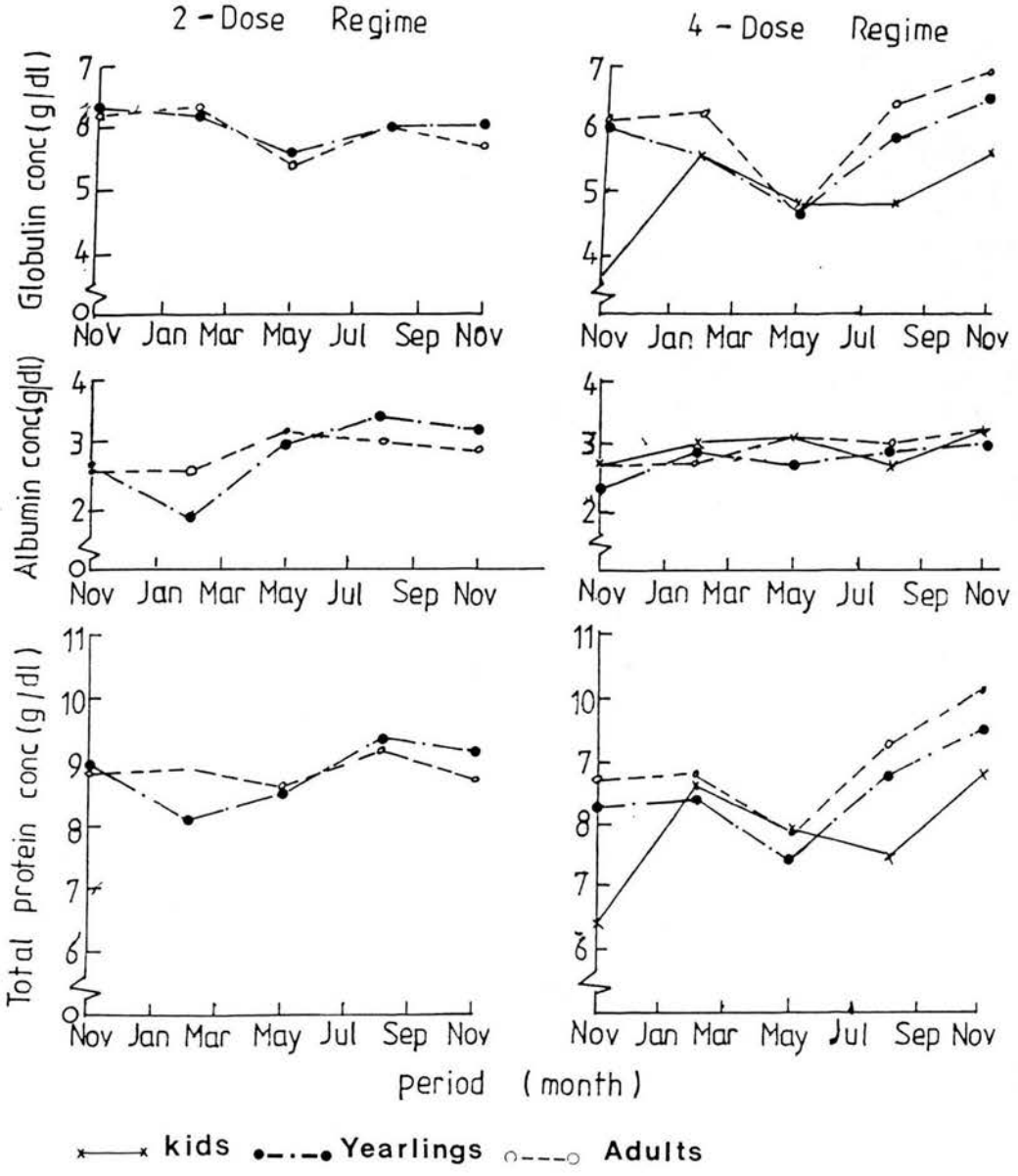


Figure 46 Serum protein changes in goats under 2-dose and 4-dose anthelmintic regimes at Mankon, Cameroon.

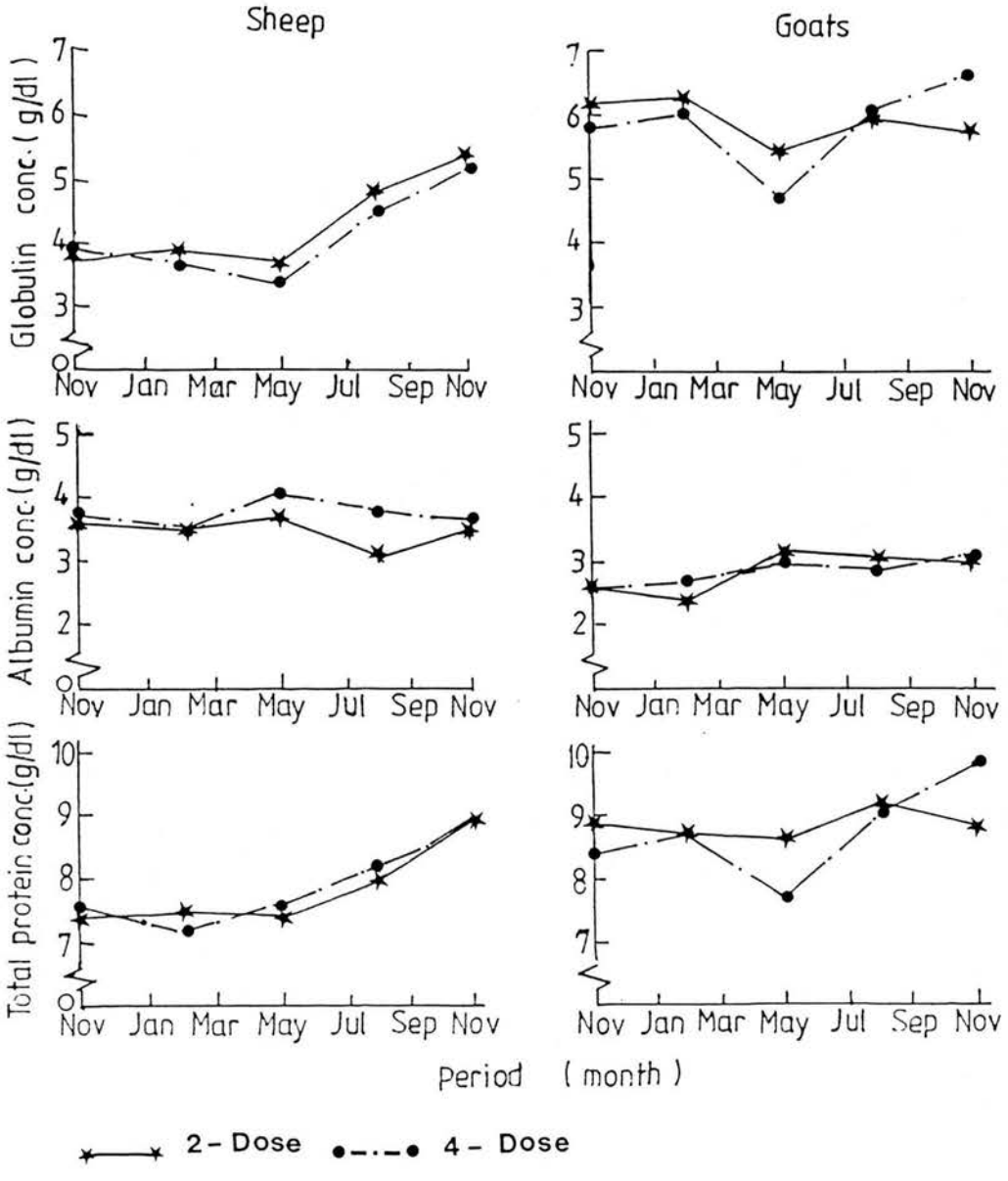


Figure 47 Serum protein changes in sheep and goats under 2-dose and 4-dose anthelmintic regimes at Mankon, Cameroon.

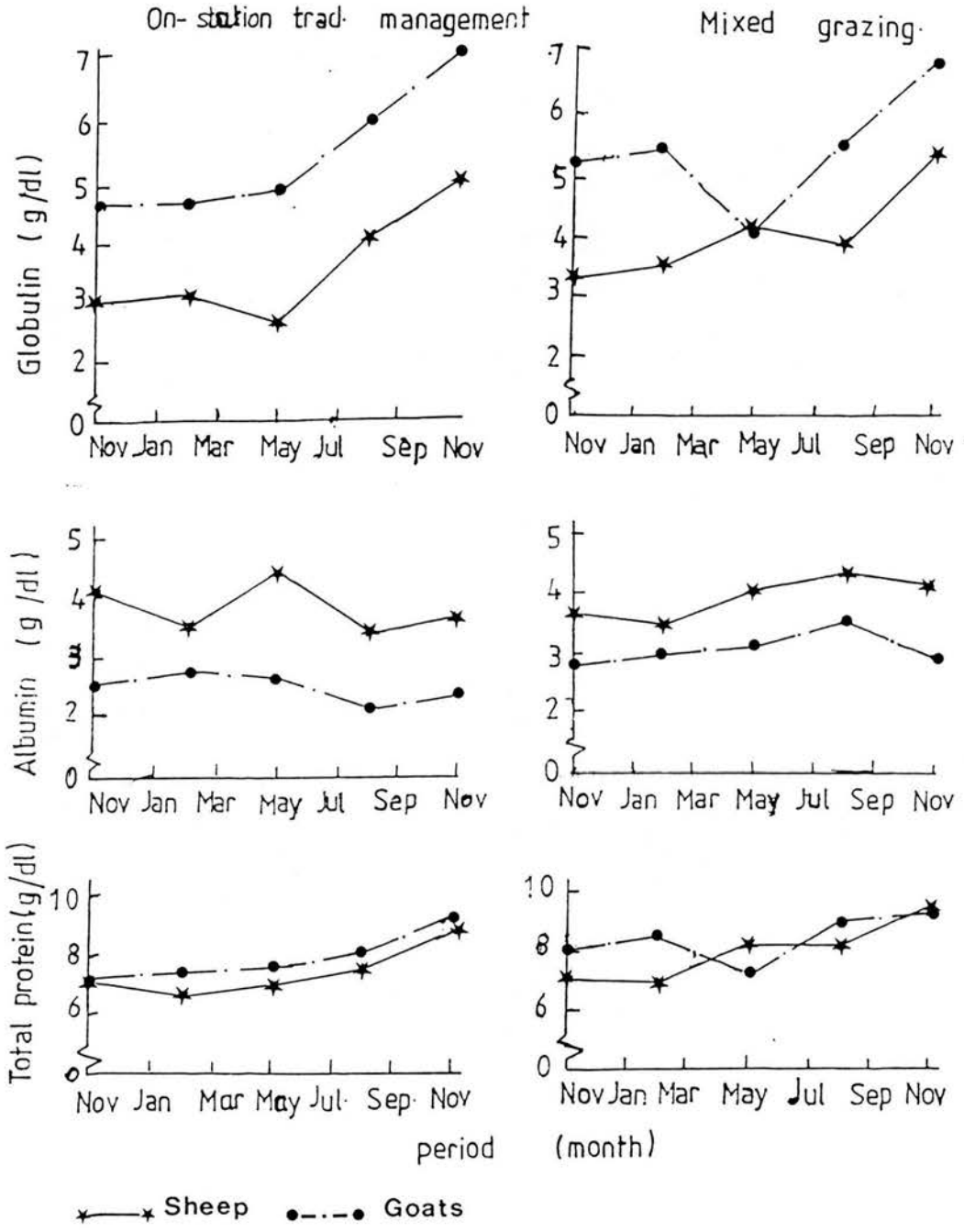


Figure 48 Serum protein changes in sheep and goats under on-station traditional management and mixed grazing.

although the adults generally tended to have higher total protein and globulin and lower albumin values than the lambs (Figure 45).

In the goats on the two differing anthelmintic regimes (Figures 46 and 47) the total serum protein and globulin values decreased between February and May, the decrease being significant in the animals on 4-dose anthelmintic treatment (total protein: $P < 0.05$, globulin $P < 0.01$). Thereafter the total protein and globulin values increased consistently up to November in animals on the 4-dose anthelmintic ($P < 0.001$ for both parameters) while the values were somewhat lower in animals on the 2-dose anthelmintic regime after August. The albumin values, on the other hand, increased slightly between February and May and then remained more or less constant for the rest of the period.

The sheep and goats on mixed grazing (Figure 48) showed a similar pattern of variation in the values of serum albumin. The concentration increased gradually but consistently between February and August, then fell towards the end of the rainy season. The total protein and globulin concentrations in goats were minimal in May and then increased more or less consistently thereafter. The increase in globulin between May and November was significant ($P < 0.002$). The total protein and globulin concentrations in sheep increased more or less consistently from November and the globulin concentration recorded at the end of 12 months was significantly higher than the initial value at the start of the studies ($P < 0.001$).

The on-station traditionally managed animals displayed a similar pattern of change in serum protein and protein fractions (Figure 48). The values did not change significantly between November and May but thereafter total protein and globulin concentrations increased while the albumin decreased.

Thus, given the consistent differences between sheep and goats, there was a similarity in the plasma protein patterns in all the groups in both hosts with a tendency for the albumin levels to remain fairly constant and for the globulin levels - and hence the total protein levels - to fall or to remain static between November and May and then to rise, often being above the initial level in September, with either a peak in that month or a further rise in November. No consistent differences were found beteween ages or treatment groups but some of the changes with time were significant.

The comparisons of the albumin/globulin ratio for sheep and goats under different management systems are presented in Figure 49. Apart from the tendency for the ratio to fall overall and to be higher in May, there was

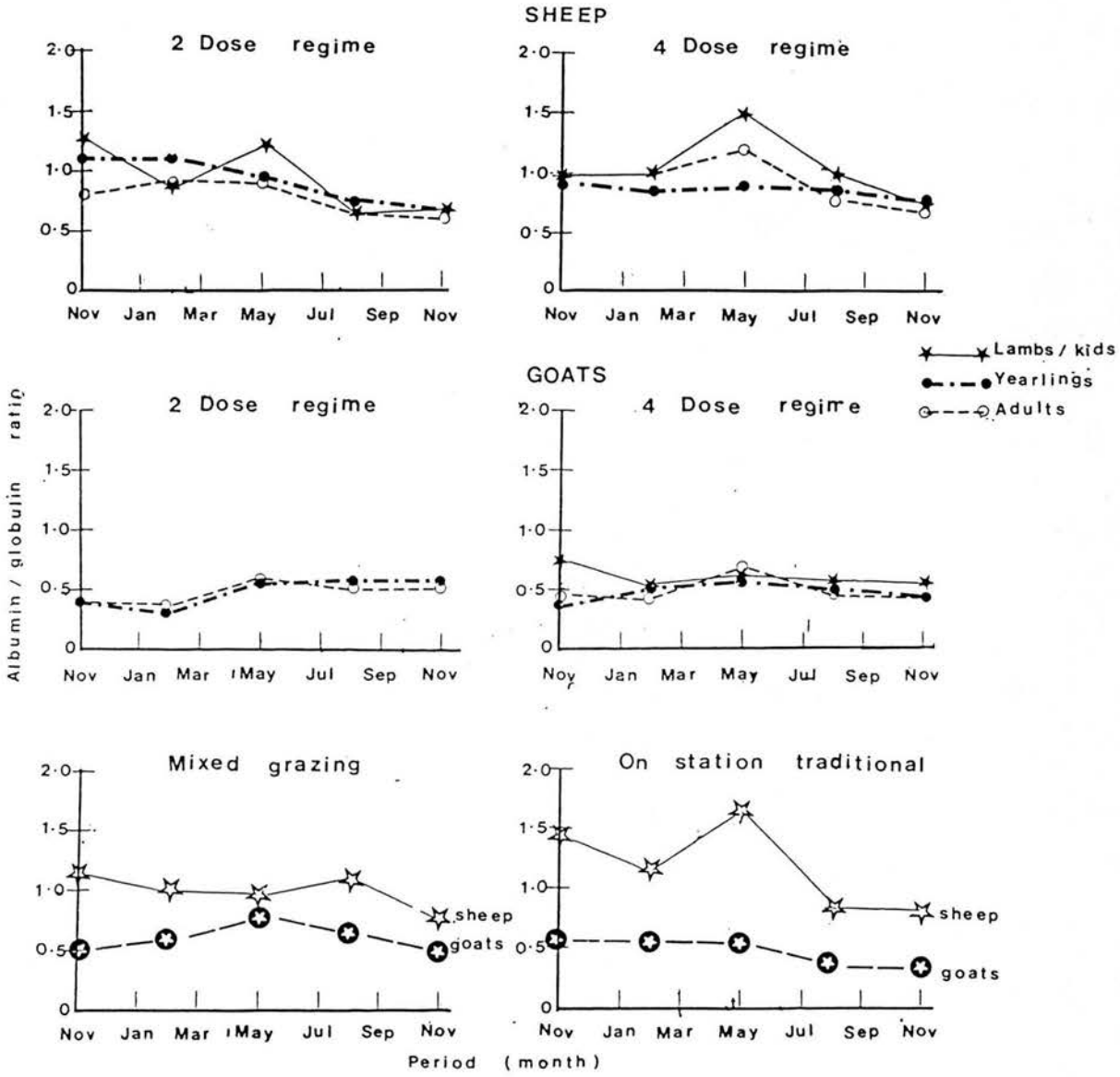


Figure 49 The average albumin/globulin ratio of sheep and goats under different management systems at Mankon, Cameroon.

little change throughout the year in any of the groups. The overall fall was significant ($P < 0.001$) in the sheep on 2-dose and 4-dose anthelmintic regimes while the peak in May was significant only in lambs of the 4-dose group ($P < 0.01$).

DISCUSSION

Productivity and parasitology

The 1985-1986 epidemiological study comparing a 4-dose and a 2-dose anthelmintic regime with an effective anthelmintic being used from March onwards, gave similar results for both systems. However, despite the use of a relatively ineffective anthelmintic in December, the fact that the faecal egg counts in the 4-dose groups were consistently lower than those of the 2-dose groups throughout the dry season suggests that the use of an effective anthelmintic at that time would probably be of value. This second year's results thus confirmed the earlier conclusion that at most four strategic treatments and probably only three are needed for optimum productivity of sheep and goats in the North West Province of Cameroon under adequate grazing and supplement management routines.

The possibility that the high egg count in the goats at Mankon may have partly resulted from the rotational grazing was confirmed by the results of the 1985-86 epidemiological study where the goats were set-stocked and faecal egg counts were low throughout the year including the rainy season period. This study may have been confounded by the use of levamisole but the results in Figure 38 suggest that goats were tending to acquire heavier infections than the sheep in the rains, whereas they did not do so under the simulated or real village systems.

Despite the low egg counts in the sheep and goats at Mankon during the 1985-86 study, considerable weight losses were recorded in the sheep, especially in the yearlings and ewes, in contrast to the observations in 1984-85 when the animals showed significant weight gains. The high lambing rate, especially between September and November, was probably responsible for the weight losses observed. In the 1984-85 study, no lambings took place after September to have similarly affected the weight gains. The sheep were breeding towards the end of the rains and since adequate forage was not available at this time as most of the succulent herbage had been eaten off leaving only mature pasture, the breeding rams tended to lose weight.

In contrast to the 1984-85 study, a high mortality rate was recorded with the research station's goats during 1985-86. Although most of the

animals that died harboured worm burdens in sufficient numbers to have contributed to their death, helminthiasis did not appear to have been the primary cause of the health problems in the goats, especially as the egg counts in the surviving animals remained very low throughout the year. *Oestrus ovis* larval infestation was a particular problem amongst the goats during this year. Infestation with these bots interferes with the normal grazing of the animals and often results in sore noses. Infection with up to 10 or more bots is likely to interfere with the normal development of the sheep (Hall, 1977). It is possible that infestation of the animals with these larvae, by interfering with their normal feeding, may have resulted in malnutrition and enhanced their susceptibility to helminth infections, the precipitating cause of the deaths. This hypothesis merits further experimental study. *Oestrus ovis* larvae have been found to be common in the nasal cavities of Nigerian sheep and goats (Akerejola *et al.*, 1979). Unsworth (1948) examined 220 goats and found up to 44 percent infected, the highest incidence being during the dry season. At Mankon between January and April 1986, 15 of the 40 goats on the 4-dose and 2-dose anthelmintic regimes had died, including all those that were investigated for this parasite. *Oestrus ovis* larvae in these animals averaged above 10. Sneezing and nasal discharge resulting from irritation of the mucus membrane in the nasal passages and sinuses were the common signs of infestation. All the animals that died were not investigated for this parasite because the contribution of *O. ovis* larvae to their deaths was only suspected when some larvae were seen along the trachea at post-mortem examination.

In the study at Mankon where sheep and goats grazed together, the survival rate was higher in sheep than in goats. The set-stocking grazing management combined with the strategic anthelmintic treatments given in May and July kept the faecal egg counts low but with slightly higher counts in goats than sheep. The poor performance of these animals was probably a result of the poor quality of the forage on which they were grazing. In addition the goats may have suffered from the detrimental effects of helminth infections. Soulsby (1982) speculated that the browsing habit of goats, which protects them from heavy infections, may have resulted in their failure to evolve effective resistance mechanisms against the common gastrointestinal nematodes of ruminants and that this may account for the greater susceptibility of goats to these parasites. Pomroy *et al.* (1986) arrived at the same conclusion from a study he made on sheep and goats grazing on the

same pasture. The goats under both village conditions and simulated village conditions at Mankon appeared to have been protected from heavy helminth infections by their browsing behaviour.

The deaths recorded in traditionally managed sheep and goats during 1985-86 were attributed to helminthiasis and tick infestation. The deaths all occurred in the flocks of two of the cooperating farmers who had tethered their animals throughout the year on limited grazing land with little access to browse. This suggests that tethering may in some circumstances result in a heavy build up of helminth infective larvae on the pasture and so may precipitate heavy infections in animals grazing such pastures. Tick infestation was a problem at the onset of the rains. Ticks cause major losses of livestock production both through their blood consuming ability and also from their ability to transmit various bacterial, viral, protozoal and other diseases (Hall, 1977). However, evidence for these was not looked for in the present study.

The on-station simulation of traditional management was successful in that it replicated the greater survival rate of goats under traditional management.

Since the same pastures were used in both years of the epidemiological study, the pattern of pasture larval availability can be observed to be continuous (Figures 9, 41 and 42) from 1984-86. On the sheep pastures there was an obvious decline in pasture larval counts from November. On the goat pastures, since the late rainy season peak had been reached much earlier than on the sheep pastures, pasture larval counts were already low by the end of November. The change in the management systems of the animals grazing these pastures may have partly accounted for the change in time of the peak periods of pasture larval availability during the rainy season of 1985-86. The timing of rainfall was, however, similar in both years of the epidemiological study.

The low rate of pasture larval contamination observed on the sheep pastures at Mankon during 1985-86 largely reflects the absence of clinical parasitic gastroenteritis in the flock and indeed there was only one death that was attributed to this disease. On the other hand the higher larval counts obtained for the goat pastures at Mankon and for the traditionally managed pastures at Batibo are concomitant with the high mortality recorded in the animals grazing on these pastures throughout the year. The heavy worm burdens in the animals that died in January 1986 were probably from infections acquired in the latter parts of the rainy season and emphasizes the

value of treatment with an effective anthelmintic early in the dry season.

The results from the pasture larval identification and necropsies confirmed the studies in 1984-85 using tracer animals regarding the seasonal fluctuations of nematode infestations in sheep and goats in the North West Province of Cameroon.

Haematology

The PCV levels in sheep and goats on 2-dose and 4-dose anthelmintic regimes in the rains of 1985-86 appeared higher than their values in sheep and goats on standard and reduced anthelmintic regimes in the rains of 1984-85. Since this probably resulted from the use of a more effective anthelmintic for helminth control in 1985-86, we may conclude that helminth infections play a role in production losses in small ruminants and these, along with tick infestation and dry season nutritional stress, may be largely responsible for the lowered blood values in Cameroon sheep and goat breeds.

As the seasonal pattern of the PCV was similar between the 4-dose and 2-dose groups of each species, it would seem again that the use of fewer anthelmintic treatments may be preferred for the economically optimum productivity by small ruminants.

Serum biochemistry

There was no significant difference in the values of the serum biochemical parameters between animals of the same species on the 4-dose and 2-dose anthelmintic regimes. There was a gradual decrease in the A/G ratio during the wet season for animals in all management groups at Mankon. This reflected the lower worm burdens in those animals as evidenced by the low egg counts.

CONCLUSION

These studies have shown that helminthiasis probably plays an important role in production losses in small ruminants in the North West Province of Cameroon. It would appear that the frequency of anthelmintic treatment of sheep and goats can be reduced to only three strategic treatments, given early in the dry season, in May and in July each year, without having any significant effect on the survival or productivity of the animals. In order to take advantage of the unfavourable conditions for transmission or development of helminths that prevail during the dry season to eliminate a residual worm burden by chemotherapy, perhaps the dry season treatment should be given in or before the driest month (January). Chiejina (1986) suggested that such treatment should be accompanied by movement of the animals to clean pastures at the start of the rains. However, it might be better done straight after treatment in an area such as North West Province of Cameroon where some infective larvae persist on the pasture throughout the dry season.

The goats at Mankon were found to perform relatively poorly even under set-stocking grazing management. The role of browse in reducing their chances of acquiring pasture transmitted parasite infections has been emphasized (Soulsby, 1982; Schillhorn van Veen, 1982).

Oestrus ovis larval infestation rather confounded the results obtained for helminth control in goats under set-stocking grazing management. Recent anthelmintic trials carried out by Yazwinski *et al.* (1983), Swan *et al.* (1984) and Dakkak *et al.* (1986) have shown that Ivermectin given either as a subcutaneous injection or as a drench at 200µg/kg body weight is highly effective against the parasite, eliminating all three instars of *Oestrus ovis* larvae as well as a wide range of gastrointestinal nematodes and lung worms. A study of the use of Ivermectin is therefore strongly recommended for goats in the Bamenda area.

PART IV

EXPERIMENTAL STUDIES

INTRODUCTION

The experimental studies were intended to provide more information on the development and pathogenesis of the nematode parasites, especially *Haemonchus contortus*, important in parasitic gastroenteritis and to compare in detail the reaction of sheep and goats to infection with these parasites. An attempt was made to replicate some of the epidemiological patterns seen in the field such as the sudden exposure of animals to heavy infections or to an infection increasing at an escalating rate or to a continuous intake of low levels of infective larvae. It was hoped that the information obtained from these studies would reflect and amplify the epidemiological findings.

MATERIALS AND METHODS

LOCATION

These studies covered the period from October 1983 to June 1987. The experiments carried out during the first year were conducted at the Centre for Tropical Veterinary Medicine (CTVM), Roslin, Midlothian, Scotland. During the rest of the period the work was carried out at the Animal Research Station at Mankon, Cameroon.

ANIMALS

The animals used at the CTVM were Scottish Blackface sheep and Saanen and Toggenburg goats. Those used in Cameroon were Grassland Dwarf sheep and goats and Red Sokoto goats (Plates 1–3).

Animals for experimental infections

All the animals used for experimental infections were kids and lambs reared indoors from birth under conditions which so far as possible precluded adventitious infections. Those used at the CTVM were kept on concrete floors which were cleaned, disinfected, dried and bedded down with wood shavings every day. They were checked occasionally for the presence of eggs in their faeces using the differential centrifugal flotation technique. They were fed artificial milk until they were eight weeks old in addition to 5 kg hay/animal/day and 1 kg of oats/animal/day. Water was provided *ad libitum*.

The experimental animals at Mankon were reared on raised wooden

slatted floors that were cleaned daily. Until they were weaned at two months of age, they were kept with their dams at night to suckle. They were later fed 0.25 kg/animal/day of a concentrate containing 16-18% protein (Table 16) in addition to fresh herbage of elephant grass. Water was provided *ad libitum*. Faecal egg counts were carried out fortnightly by differential centrifugal flotation technique to ensure that they had not been accidentally infected. When any animal was found to be infected, all were treated with Ivermectin 200 µg/kg body weight but such adventitious infections were rare.

CONTROLLED INFECTIONS

Three strains of *Haemonchus contortus* were preserved in their respective host animals to serve as a source of eggs for monospecific larval cultures. These were a Mankon goat-adapted (LG), Mankon sheep-adapted (LS) and Moredun sheep-adapted (ES) strain. The ES strain had been established at the Animal Diseases Research Association, Moredun, Edinburgh by surgical transplantation of 14 day-old male and female *H. contortus* from donor sheep. This strain was maintained locally at Mankon in a Dorset male lamb. Only one maintenance host was used because of the unavailability of another suitable host. The Mankon strains were established by culturing eggs from mature gravid female worms. These had been obtained alive at necropsy from naturally infected Grassland Dwarf sheep and goats which had died or were killed in extremis, and left in a small quantity of physiological saline in petri dishes at room temperature to lay eggs for as long as they remained alive. The saline containing the eggs was poured onto sterile ovine or caprine rumen contents which had first been dried in the sun and then in an oven at 105°C for 12 hours. The rumen contents and saline containing the eggs were thoroughly mixed and water was added to obtain the consistency of goat/sheep faeces. The larvae obtained from these cultures were administered to a recipient male lamb or kid which served as the maintenance host. The strains were built up by giving the animals several such infections and then further increased by culturing faeces from the maintenance animals once the initial infection had established and reinfecting them once or twice to maintain an egg count of at least 1000 epg faeces. The animals were monitored fortnightly to ensure that they did not lose their infection. If the egg count was observed to be dropping, the maintenance host concerned was reinfected with 5000 L_3 given in five daily doses of 1000 L_3. However, passage into fresh hosts was carried out twice for the LS strain but not for the LG and ES strains because of the difficulty of obtaining other suitable maintenance hosts. Male

maintenance hosts were preferred as they afforded an easy way of collecting faeces free from urine by means of a faecal bag (Plate 10). This was tied round the anus, between the hind legs and fastened to the cord holding the neck tag.

All infections were given orally using a plastic syringe (1-10 ml, depending on the dosage). The dose was expressed into the throat and washed down with a large volume of water.

HISTOLOGICAL TECHNIQUE

A block of tissue 1.5 x 5 cm was removed from the same fundic and pyloric areas at post-mortem examination of every animal for histology and placed in 10% buffered formal saline. They were processed in the Department of Veterinary Pathology at the CTVM using standard techniques.

HAEMATOLOGICAL TECHNIQUES

BIOCHEMICAL TECHNIQUES

STATISTICAL ANALYSES.

These techniques are described under the section on epidemiological studies.

Plate 10 Faecal collection from male sheep using a faecal bag.

EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF LARVAE OF *HAEMONCHUS* AND *OSTERTAGIA*

INTRODUCTION

The study was undertaken in an attempt to devise a procedure for obtaining and maintaining a pure strain of *Ostertagia circumcincta* from a culture of mixed strongyle-type eggs by cool temperature development. This method was intended for use in establishing heterogenous field-derived strains of *O. circumcincta* for a proposed study on the possibility of inducing drug resistance against new anthelmintics. In the event it was not possible to carry out the latter study for logistic and technical reasons but the initial study provides interesting results.

EXPERIMENTAL DESIGN

Faeces containing *Haemonchus contortus* eggs or *Ostertagia circumcincta* eggs were obtained from sheep with experimental monospecific infections at the Animal Diseases Research Association. The faecal pellets were placed on absorbent gauze in separate culture boxes of the type described by Pullan and Sewell (1980). The boxes were held in constant temperature chambers kept in a constant temperature room at 5°C. The constant temperature chamber used was a rectangular box of 25 mm thick polystyrene, measuring 430 x 295 x 230 mm deep (outer dimension) with a lid and containing a flat 16W heating element (Jemp Engineering Ltd., Langley, Bucks.). Each element was connected through a variable resistance to a variable transformer and the chosen temperature for each box was preset by regulating the voltage and resistances. Temperatures of 8°C, 11°C, 15°C and 19°C were obtained in this way. Other culture boxes without heating elements were placed in constant temperature rooms at 5°C and 22°C rspectively.

The faeces were periodically moistened to maintain a water content comparable to that of freshly passed faeces. Each day eggs were extracted by flotation in saturated sodium chloride solution from samples of faeces containing each nematode at each temperature and examined to determine the progress of the development of the larvae. For each sample 100 eggs were observed under a compound microscope and the stage of embryogenesis classified according to Silverman and Campbell (1959) and Christie and Jackson (1982). As soon as eggs were observed in the prehatched stage, a miniature Baerman (Ministry of Agriculture, Fisheries and Food, 1979) was also set up at each examination to extract the larvae from one gram of the

incubated faeces. The total number of larvae so obtained was then taken to be the number of larvae per gram of faeces. For each examination 50 larvae were classified as non-infective (1st stage and 2nd stage) or infective (3rd stage) larvae. The length and breadth of the larvae produced at each temperature were also measured after they had been killed with a little iodine solution.

RESULTS

The observations on the rates of embryonation, hatching and larval development of *Ostertagia circumcincta* and *Haemonchus contortus* at the different constant temperatures are summarised in Table 38. It was noted that eggs in the same faecal culture behaved in different ways in that:-

(a) their development proceeded at different rates;

(b) some failed to develop or died at different stages of development due to unknown causes.

The data presented in Table 38 brings out the following information regarding development at the temperatures studied.

The eggs of *O. circumcincta* and *H. contortus* were normally in the early morula stage at the commencement of incubation except perhaps for some that were already dead. Whereas the eggs of *H. contortus* never developed any further at 5°C, those of *O. circumcincta* developed through the different stages of embryonation, rather slowly, some hatching after 19 days of incubation. The infective stage was reached after 75 days. Eggs of *H. contortus* transferred successively through 8°C, 11°C, 15°C and 19°C, and being left for one week at each temperature after three weeks at 5°C failed to develop.

At 8°C *O. circumcincta* hatched after 4-5 days of incubation and 50% of the larvae were infective by 15 days. By contrast the majority of the *H. contortus* eggs remained undeveloped.

At 11°C 96 percent of the *O. circumcincta* had reached the prehatch stage after two days of incubation and hatching took place after five days. This was the lowest temperature tested at which *H. contortus* developed to infective stage.

At 15°C infective larvae of *O. circumcincta* and *H. contortus* were obtained at approximately the same time and more than 50 percent of the larvae had reached the infective stage in both species by the seventh day. At both 19°C and 22°C the development rates of the two species were similar.

Table 38 Development of the free-living stages of *Ostertagia circumcincta* and *Haemonchus contortus* at different constant temperatures

Stage of development	First day after the culture was set up at which each stage was seen											
	5°C		8°C		11°C		15°C		19°C		22°C	
	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.
Gastrula	3	-	1	3	2	2	1	1	1	1	1	1
Tadpole	4	-	2	4	2	3	1	1	1	1	1	1
Prehatch	9	-	3	6	2	4	1	2	1	1	1	2
Non-infective larvae	19	-	5	-	5	6	3	3	2	2	2	3
Infective larvae	75	-	15	-	10	16	7	7	3	4	3	5

O.c. = *Ostertagia circumcincta*

H.c. = *Haemonchus contortus*

Table 39 Comparative growth of larvae of *Ostertagia circumcincta* and *Haemonchus contortus* at various constant temperatures

Age of larvae (days)	Average length of larvae (µ) 5°C		8°C		11°C		15°C		19°C		22°C	
	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.	O.c.	H.c.
1	401	-	424	259	435	345	423	375	584	510	555	423
2	-	-	469	308	506	388	538	456	827*	700	811*	575
3	435		518	315	543	405	617	561	-	750*	-	738*
4	-	-	563	413	628	448	764	647				
5	443	-	589	304	720	454	827*	746				
6	-	-	630	323	810	515	-	754*				
7	405	-	671	-	843*	534						
8	-	-	755	353	-	528						
9	420	-	776	-	-	580						
10	-	-	853	-	-	632						
11	486	-	841*	-	-	625						
12	-	-	-	345	-	716*						
13	510											
16	509	-	-	315								
58	689											

*Average length of L_3 infective larvae

O.c. = *Ostertagia circumcincta*

H.c. = *Haemonchus contortus*

A comparison of the growth rate of the larvae of *O. circumcincta* and *H. contortus* is presented in Table 39 for the various temperatures. Newly hatched 1st stage larvae were much smaller when hatched at lower temperatures than at higher temperatures. The growth rate was much slower

at lower temperatures than at higher temperatures (Figures 50 and 51), the larvae of *O. circumcincta* in all cases growing faster than the larvae of *H. contortus*. However the 3rd stage infective larvae of *O. circumcincta* attained their greatest length at 11°C while those of *H. contortus* were largest when cultured at 15°C (Table 39).

There was generally a greater size variation among larvae developing in the same cultures at the lower temperatures (15°C or less) than at the higher temperatures (19°C or more).

DISCUSSION

The results of this study are in agreement with those of earlier authors such as Veglia (1915), Mizelle and Berberian (1953), Silverman and Campbell (1959) and Soulsby (1965) in that *H. contortus* failed to develop at 5°C and developed poorly at 8°C while the optimum temperature for the species appeared to be 15°C. The results for *O. circumcincta* also conform with those reported by earlier workers such as Crofton (1965) and Salih and Grainger (1982) in that hatching and development to infective stage occurred at temperatures as low as 5°C while the optimum temperature for the species appeared to be 11°C.

From the results of this study, it appears that 11°C or a little lower would be the most convenient temperature at which infective larvae of *O. circumcincta* could be obtained at the shortest possible time with minimal risk of contamination by infective larvae of *Haemonchus*. Wang (1967) reported that *T. colubriformis* reached infective larvae at 10°C only after 22 days of incubation. The risk of contamination from *Chabertia* which has been shown to hatch at similar low temperatures to *O. circumcincta* (Crofton, 1963) would best be avoided by culturing faeces void of *Chabertia* eggs.

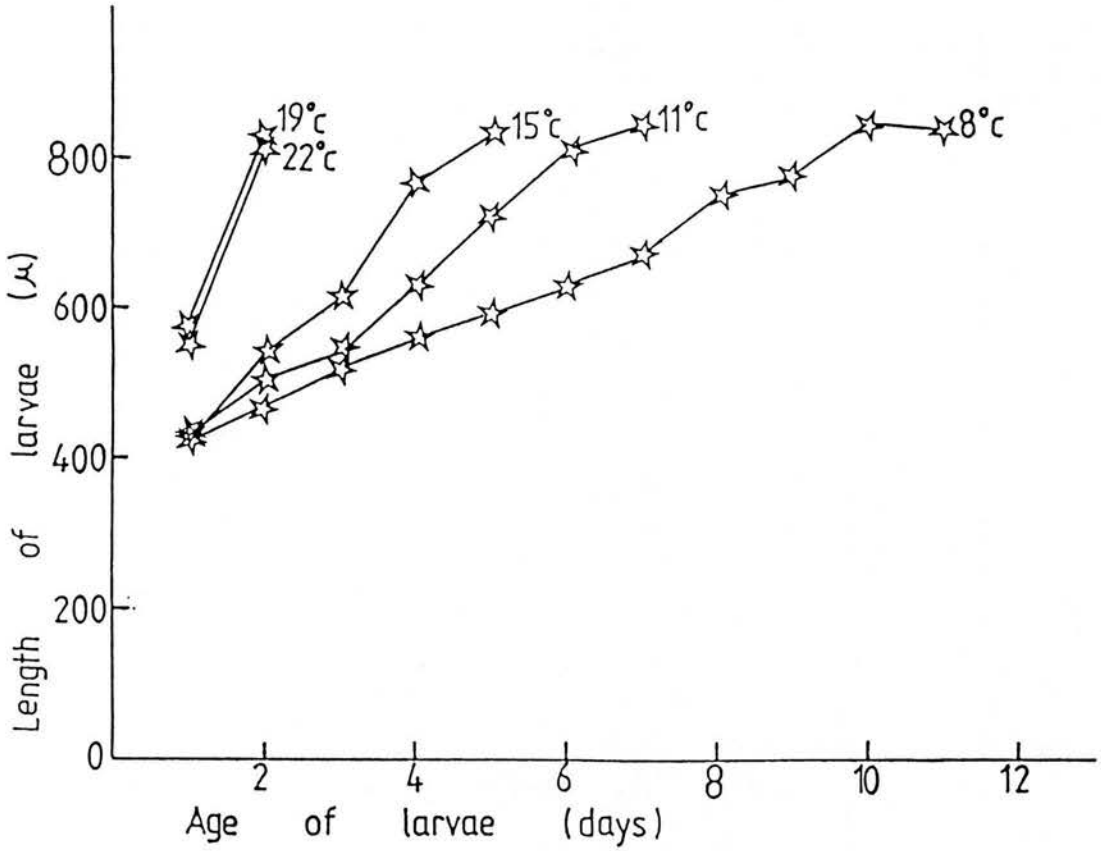


Figure 50 Comparative growth of *O. circumcincta* larvae at various constant temperatures.

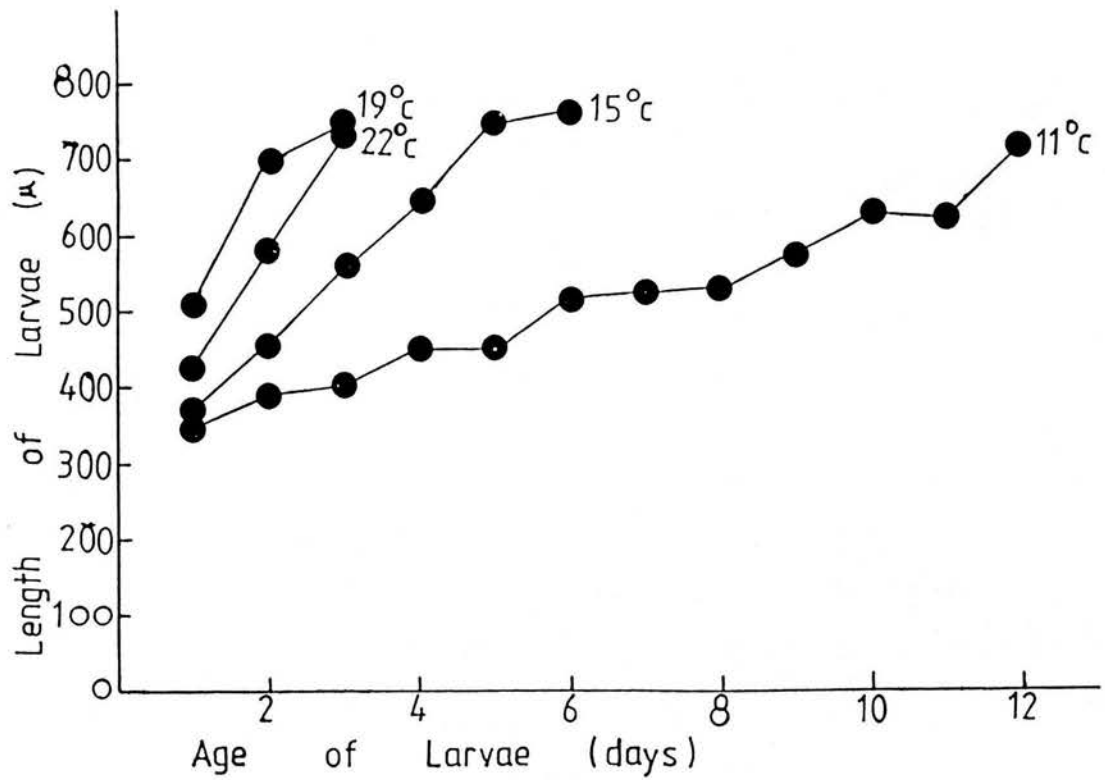


Figure 51 Comparative growth of *H. contortus* larvae at various constant temperatures.

SINGLE EXPERIMENTAL INFECTIONS WITH *HAEMONCHUS CONTORTUS*

AT THE CTVM

INTRODUCTION

The gross pathological and histopathological changes that take place in the abomasum of sheep following a single challenge dose of *Haemonchus contortus* have been reported by Silverman and Patterson (1960), Charleston (1965) and Hunter and Mackenzie (1982). Because of the apparent lack of similar studies in goats, the present experiment was intended as a pilot study to compare the establishment and pathogenic effects in sheep and goats of a strain of *H. contortus* that had been maintained for many generations in sheep.

EXPERIMENTAL DESIGN

Four parasite-free Blackface lambs, approximately 4 months old and four kids (2 Toggenburgs and 2 Saanens) of similar age, were selected from the laboratory stock and given a single dose of 10,000 infective larvae of *H. contortus* (ES strain).

Individual lambs and kids were killed at 4, 8, 14 and 18 days after infection. A single uninfected lamb and a similar kid were killed towards the end of the experiment as uninfected controls. The developmental stages of the worms observed were classified as 4th stage larvae, 5th stage larvae, non-gravid adult females, males with developing bursae and sexually mature male and gravid female adults. Half the abomasal wall was removed using the edge of a glass slide for digestion and identification of tissue stages. A 1.5 x 5 cm block of tissue was removed from the same fundic area in every animal for histology. The abomasal tissue portions were fixed in 10% buffered formol saline for seven days. After routine processing they were blocked in paraffin wax and 5µm sections cut and stained in haematoxylin and eosin.

At least 15 adult worms and 15 4th stage larvae of each sex from a well mixed sample of the worms recovered from each animal were measured to obtain values for the length and breadth of the male and female worms in that animal. The adult worms were straightened out on a dry clean glass slide placed over a ruler on the stage of a stereomicroscope and their lengths measured. A calibrated compound microscope was used to measure the breadth and also the length of the 4th stage larvae.

Other parameters studied included the packed cell volumes and haemoglobin concentrations of blood samples collected at three and four day intervals alternately.

RESULTS

Clinical Manifestation of Infection

No clinical manifestation of infection was observed during the 18 day period.

Haematology

Figure 52 shows the packed cell volumes (PCV) and haemoglobin concentrations (Hb concentration) as percentages of the preinfection values. The actual data is shown in Appendix 11. There was no consistent change in the PCV or Hb concentration during the first 10 days in either host. However, in lambs there was then a rapid decline in the values of both these parameters. This did not occur in the kids.

Table 40 Counts of *H. contortus* recovered from the abomasum of lambs and kids dosed with 10,000 larvae (ES) at the CTVM

Age of parasite following infection (days)	Total *H. contortus* recovered				Sex ratio (female:male)	
	Lambs		Kids			
	Abomasal digest	Abomasal washings and contents	Abomasal digest	Abomasal washings and contents	Lambs	Kids
4	398	-	508	-		
8	**14**	3700	**16**	3300	2.1:1	1.3:1
14	-	6000	-	2800	0.9:1	0.7:1
18	**34**	4900	-	2100	1.4:1	0.6:1

Parasitology

Table 40 shows the numbers of *H. contortus* recovered from the abomasal digests and washings of lambs and kids killed at different ages of the parasite. All the worms present in the abomasal digest samples on day 4 were 4th stage larvae. The mean length of the worms was not significantly different in lambs and kids (Table 41) and nor was sexual differentiation apparent at this stage. By day 8, the number of 4th stage larvae recovered from the lamb was larger than the number obtained from the kid. Examination of the abomasal surface did not reveal any worms and the worms recovered in

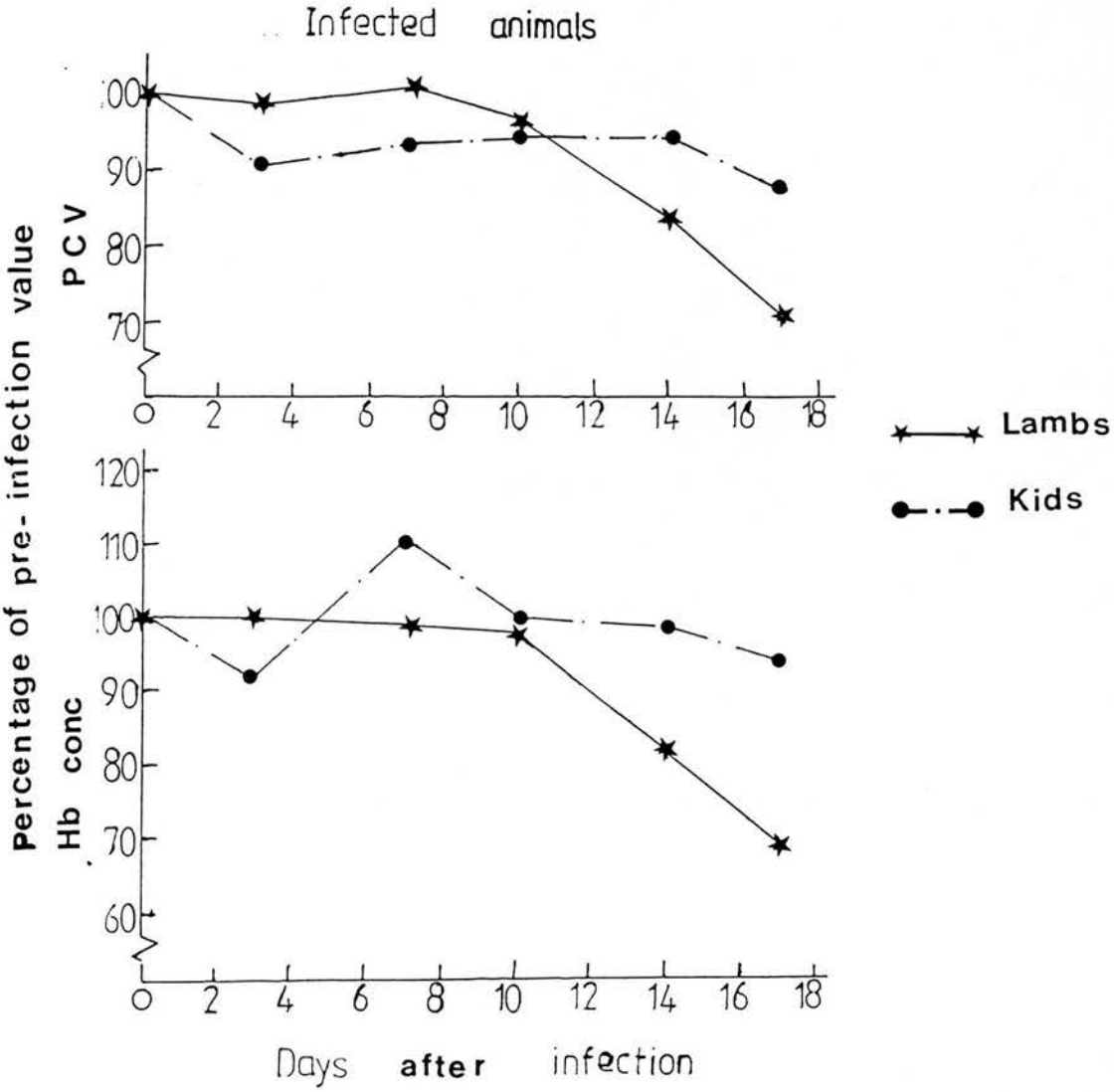


Figure 52 Changes in packed cell volume and haemoglobin concentration of European kids and lambs infected with a single dose of 10,000 L_3 of the ES strain of *H. contortus*.

the washings and contents were probably washed off in the coagulum that covered substantial areas of the fundic region. The developing bursae of the male worms could be clearly recognised through the old cuticle. In both hosts the females greatly outnumbered the males (Table 40). The worms were now about four times their size at four days. However the female worms from kids were significantly smaller ($P < 0.01$) than their counterparts from lambs. The male worms from both hosts were similar in size.

Table 41 The mean length of male and female *H. contortus* (ES) in experimentally induced infections of different ages

Age of worm (days)	Mean worm length±standard deviation (and range) (cm)			
	Lambs		Kids	
	Female	Male	Female	Male
4	0.15±0.03 (0.10–0.175)		0.13±0.02 (0.10–0.15)	
8	0.61±0.03 (0.55–0.65)	0.37±0.06 (0.3–0.45)	0.52±0.07 (0.4–0.6)	0.42±0.02 (0.4–0.45)
14	1.22±0.16 (1.0–1.4)	0.93±0.07 (0.8–1.05)	0.96±0.13 (0.7–1.15)	0.79±0.15 (0.65–1.1)
18	1.64±0.08 (1.35–1.78)	1.19±0.09 (1.1–1.4)	1.36±0.09 (1.2–1.53)	1.04±0.07 (0.8–1.13)

By day 14, non-gravid adult females and males with fairly well developed bursae were recovered only from the abomasal washings and contents. The number of worms in the lambs was more than double that in the kids (Table 40). There was now an excess of male worms over females in both hosts. The worms in the lambs had far outgrown those in the kids (female worms: $P < 0.001$; male worms: $P < 0.02$) (Table 41). The entire abomasal mucosal surface of the lamb was swarming with *H. contortus* but there were noticeably fewer in the mucosal surface of the kid.

By day 18 there was a reduction in the number of worms recovered from both hosts but the lambs still harboured more than twice as many as the kids (Table 40). The sex ratio showed a further reduction in the proportion of female worms in the kid to about half the number of males while in the lamb the females outnumbered the males.

Whereas all the female worms from the lamb were gravid, none of the

females examined from the kid were gravid. Examination of the hosts' faeces from day 16 post-infection revealed that the strongyle-type egg count in the lamb's faeces increased rapidly from 2,200 on day 16 to 10,650 on day 18. In contrast the kid's faeces contained only 100 epg on both days. There was still a very significant size difference between the worms from the two hosts, with those from the lamb being much longer (male and female: $P < 0.001$).

Gross Pathology

In the uninfected control lamb and kid the abomasal mucosa had a regular appearance with the gastric pits and folds showing a smooth surface. Four days after infection, the abdominal contents of neither the lamb nor the kid at necropsy showed any evidence of anaemia. However more dramatic changes were observed in the abomasum. In both host animals there were numerous small circumscribed areas appearing as raised white spots on the mucosal surface. These spots appeared more numerous and conspicuous in the lamb in which there were also a few small red petechiae on the abomasal surface. All the 4th stage larvae recovered were from the abomasal digest material implying that they were probably all located within and below the mucosal layer. By day 8 the gastric lobes of the fundic region of the abomasum were extensively covered with haemorrhagic areas but whereas the blood on these lesions was red and fresh in the kid, it was dark in the lamb. Moreover, these blood clots were easily washed off in the lamb but not in the kid. Streaks of clotted blood could be seen in the mucous debris under the stereo-microscope.

By day 14 almost the entire surface of the gastric lobes of the abomasum of the kid was covered with a continuous coating of coagulated blood. Between the lobes there was a thick coating of mucus. Both the blood and the mucus washed off easily indicating that the coagulum was no longer adherent. Individual worms were not easily discernable. In contrast although excess mucus was present in the lamb, there was no indication of blood except for a narrow haemorrhagic patch extending across the pyloric region of the abomasum. The entire abomasal mucosal surface was observed swarming with numerous worms.

By day 18 the abomasal surface in both the lamb and the kid had a granular appearance with no evidence of blood. The gastric folds in both hosts were pinkish in colour. Numerous adult worms could now be easily seen with the naked eye lying on the entire abomasal surface. However, there were clearly more worms on the abomasal surface of the lamb and these were

larger than those in the kid.

Histopathology

In the uninfected animals the abomasal epithelium was intact. The mucosal depth and the ratio of the mucoid and peptic parts of the gastric glands was more or less uniform throughout the entire length of the sections. Within the lumen the secreted mucus formed a layer closely lining the surface epithelium.

By day 4 after infection, the lining epithelium of the mucosa was still reasonably intact although slightly ragged in the lamb. Dilated glands and paramucosal spaces were observed. Cross sections of the parasite were seen closely attached to the mucosal surface. None were observed in the glands. Small collections of mononuclear cells, mainly lymphoid-type, were observed in the deep mucosa. A few nodular lesions were observed corresponding to the circumscribed whitish spots described above.

By day 8 post infection, the larvae were still to be seen lying adjacent to the mucosal surface embedded in the mucous lining. In the lamb some had already emerged into the lumen. There was minimal erosive surface damage in the kid. The mucosal surface of the lamb appeared to be more eroded in some places but this was only of a low degree. There was a small degree of cellular infiltration of mononuclear lymphoid-type cells and a few eosinophils in the deep mucosa. There was clear indication of mucosal hypertrophy, more pronounced in the lamb and the mucosal depth was more irregular in this host. No larvae were seen in the mucosa.

By day 14, the parasites were all in the lumen. The mucosal hypertrophy was more pronounced with clear indication of irregular thickening of the mucosa. There was increased infiltration of mononuclear cells into the *lamina propria*, with columns of cells which appeared to be migrating towards the surface. Other cell types observed in the *lamina propria* were eosinophils and plasma cells. There was clearly detectable surface erosion of the epithelial cells, which seemed less severe in the kid in which there were still many areas with an intact surface. Most of the erosion occurred at the tips of the lobes, a possible combination of mechanical and parasite damage.

By day 18, the degree of pathological damage at the pyloric end of the abomasum was negligible. There was far less cellular infiltration and again the parasites were to be seen in the lumen. In the fundic region the mucosal hypertrophy was still pronounced with increased mucosal depth.

DISCUSSION

The number of animals used for this study was quite small since it was intended as a pilot study. However, if these results do indicate that which would have been obtained with a larger number of hosts, the haematological and pathological findings obtained suggest that the Moredun strain of *H. contortus* was either more infectious in lambs or that these kids were immunologically more competent than lambs in resisting any infection with *H. contortus* or both. Even though variations exist between individual animals in their responses to experimental or natural infection with *H. contortus*, the differences in the responses of lambs and kids observed in this study were so consistent as to leave no doubt that *H. contortus* established better and produced more pathogenic effects in the lambs.

Coadwell and Ward (1975) observed that a record of the host's PCV was a more valuable means of monitoring the course of *H. contortus* infection than estimating the number of eggs in the host faeces. This is because eggs do not appear in sheep's faeces until about day 21 after infection but by day 10 it is possible to show that infection has taken place by determining the PCV. In this experiment the PCV and Hb concentration of the infected lambs were observed to be declining rapidly from day 10 post-infection whereas eggs did not appear in the faeces until about 16 days after infection. This decline from day 10 is consistent with the greater demands of L_5 larvae and developing adults, allied to the more efficient blood letting associated with the lancet formation (Hunter and Mackenzie, 1982). In kids, on the other hand, there was a gradual rise in the levels of these parameters after the first three days. This is possibly the result of an erythropoietic response by the host or a temporary polycythaemia in response to the haemorrhage and blood sucking activity of the L_4 stages (Veglia, 1915; Fourie, 1931; Pradhan and Johnstone, 1972).

A striking feature of the abomasal surface at day 4 was the presence of numerous raised white spots. Charleston (1965) and Hunter and Mackenzie (1982) explained that the raised white spots observed macroscopically were localized areas of mucosal hypertrophy, probably due to early larval activity, perhaps associated with 3rd stage larvae burrowing into the mucosa. The results from the abomasal mucosal digest confirm the observation by Hunter and Mackenzie (1982) that the developing larvae at this stage were probably located within or below the mucosa.

The gastric lobes of the abomasum at day 8 were observed to be extensively covered with haemorrhagic areas, the blood appearing fresher in

the kid than in the lamb. This suggests that the haemorrhage had started earlier in the lamb. This was confirmed at day 14 when the abomasal surface of the kid alone was still extensively coated with blood. The smaller numbers and significantly smaller size of the worms recovered from the abomasum of the kids at days 14 and 18 indicated that the two hosts respond differently to this infection.

Coadwell and Ward (1975) remarked that the critical period in the development of these worms appears to lie between days 10 and 14 of infection when the length of the worms increases linearly with time. A stable environment in the abomasum during this period would be advantageous to the worm. In the present study, no marked differences were observed in the sizes of the L_4 stages from the two hosts at day 4. Silverman and Patterson (1960) explained that in susceptible hosts, most infective larvae (L_3) have undergone differentiation and completion of the first parasitic ecdysis to the L_4 stage by the third day of infection, but no marked growth has occurred. Thereafter the larvae begin to increase in size and it is then that the growth rate seems to be influenced by the immunological state of the host and stability of the abomasal environment. It is apparent from the findings in this experiment that the major cellular changes in the abomasum of the kid between days 8 and 14 post-infection coupled with increased leakage of blood into the abomasum as a result of parasitic activity probably altered the pH and osmotic concentration at the surface of the abomasal wall (Coadwell and Ward, 1975) creating a less favourable environment for the establishment and growth of the worms. Hence the necropsies performed at days 14 and 18 revealed that the worms from the kids were greatly retarded in their development with hardly any of them attaining the gravid stage by day 18. By contrast all the female worms from the lamb had reached the gravid stage and were passing large numbers of eggs at day 18 post-infection.

According to Jubb and Kennedy (1970), the protective immunity of the host against the establishment of parasites, especially *Haemonchus*, expresses itself by any or a combination of: reduction in the total worm burden, retardation and rejection of 4th stage larvae, reduction in the proportion of female worms present and reduced egg production by the females. In the present study the continuous reduction in the number of established worms with age of the infection in kids, as revealed at necropsies, may be a reflection of such an immunological response by the host.

The location of the parasites at days 14 and 18 indicates that they had

completed their development in the mucosa and were already in the abomasal lumen. The increased damage of the mucosal surface observed from day 14 therefore reflects the establishment and maturation of the adult worms (Hunter and Mackenzie, 1982). The buccal lancet which developed at the L_5 stage is especially adapted for this purpose. According to Charleston (1965) and Hunter and Mackenzie (1982), the cellular infiltration by mononuclear lymphoid-type cells, eosinophils and plasma cells is a response to the haemorrhage and damage caused by the combined effects of L4, L_5 and mature adult worms. Charleston (1965) attributed the cellular responses to the need to repair the tissue damage induced by the parasite, to expel the established worm population and to prevent establishment of another one.

SINGLE EXPERIMENTAL INFECTIONS WITH *HAEMONCHUS CONTORTUS* AT MANKON

INTRODUCTION

The establishment and pathogenicity of the Moredun strain of *Haemonchus contortus* in indigenous sheep and goats was compared with two local strains isolated from the animals at Mankon. Since these animals had at one time or another grazed in mixed flocks, the study would provide information on whether there were separate sheep/goat strains of *Haemonchus*. The infections were carried out in sequential series because of the difficulty of obtaining sufficient numbers of helminth-free animals at one time for all the experiments in progress.

EXPERIMENTAL DESIGN

In sequential experiments the response of indigenous lambs and kids to single infections with 10,000 infective larvae of the three strains of *Haemonchus contortus* was studied using the full range of parasitological, haematological and biochemical techniques as used in the epidemiological studies.

Fifteen parasite-free lambs (14 of the Hb BB and one of the Hb AB phenotypes) and 15 parasite-free kids (13 of the Hb BB and 2 of the Hb BC phenotypes) of the Grassland Dwarf breeds of sheep and goats respectively were selected from the laboratory stock and given a single dose of 10,000 infective larvae of *H. contortus* (5 lambs and 5 kids receiving each strain of *H. contortus*). The animals used for the infections were aged between three and six months.

Individual lambs and kids were killed at 4, 8, 11 (except for the LG strain), 14 and 18 days after infection for parasitological investigation and examined as described in the epidemiological studies. A single uninfected lamb and a similar kid were killed towards the end of the experiment as uninfected controls.

RESULTS

Clinical Manifestation of Infection

No clinical manifestation of infection was evident during the 18 days except in kids where the paleness of the conjunctiva after the ninth day of infection and of the carcase at necropsy were possible indications of ensuing anaemia.

Haematology

Figure 53 shows the PCV, Hb concentration and RBC plotted as a percentage of the preinfection level. The actual data is shown in Appendix 12. In all the infections, the values of these parameters were more severely lowered in kids than in lambs for 12 days after infection. In both kids and lambs there was a more or less steady decline in the values of PCV, Hb concentration and RBC, gradual at first and then more steeply from about day 12 in most cases.

In the animals infected with the LG strain, all three parameters were highly reduced in both hosts by day 18 compared to the controls. The decline in the values was consistently greater in kids than in lambs.

The LS strain appeared to have been the most pathogenic of the three strains with the difference between the course of the infection in lambs and kids showing soon after the animals were infected. The PCV, Hb concentration and RBC counts of kids declined rapidly to 50%, 73% and 52.8% respectively below the preinfection level by day 18. In the lambs there tended to be a gradual decline in the values of these parameters. On day 18, the values of these parameters in the kid were all more reduced than the corresponding values in the lamb.

In the lambs infected with the ES strain there was no appreciable change in the values of PCV, Hb concentration and RBC during the first six days. After this period, the values dropped gradually but consistently to 30.4%, 32.7% and 29.2% respectively below the preinfection level by day 18. The reduction tended to be much greater than that observed in the controls. In kids the values of these parameters dropped, more rapidly than observed in lambs, up to day 12 after which there was a temporary recovery. However, on day 18, there was a further drop in PCV, Hb concentration and RBC values of the kid to 19.8%, 17.8% and 23.8% below the preinfection level.

White blood cell counts (WBC) were elevated by over 20% above the preinfection level in lambs infected with all three strains during the first nine days following infection (Figure 53). After this period there was a decline in the value in lambs infected with the two sheep strains, that of the lambs infected with the ES strain eventually dropping to 22.7% below the preinfection level. In the lambs infected with the LG strain, the count rose almost continuously throughout the 18 days post-infection to 47.5% above preinfection level in the lamb killed on day 18. In kids there was no appreciable change in the WBC count during the first 12 days after which the value dropped steeply to 35.2% below preinfection level in the kid receiving

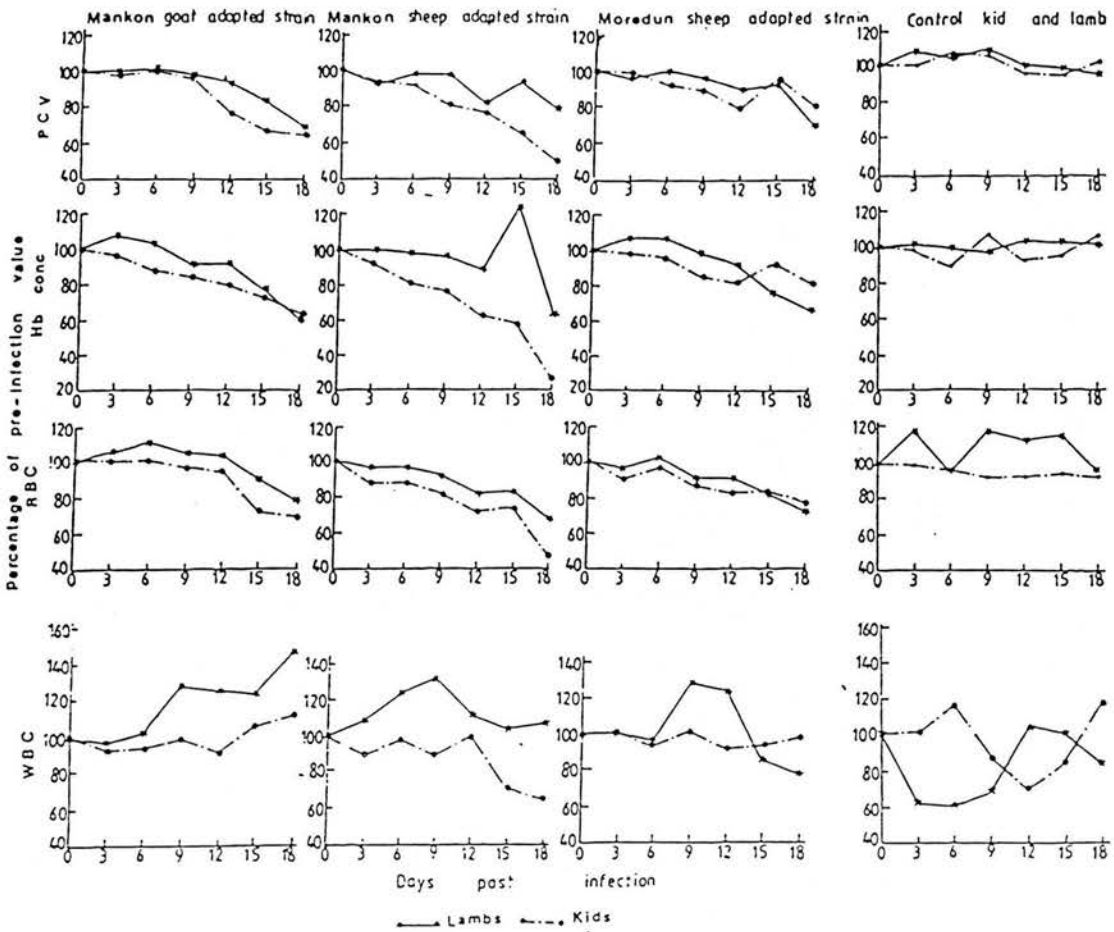


Figure 53 Changes in packed cell volume, haemoglobin concentration, red and white blood cell counts in indigenous lambs and kids infected with a single dose of 10,000 Ls of three strains of *H. contortus*.

the LS strain but rose to 11.8% above preinfection level in the kid harbouring the LG strain.

Serum Biochemistry

The changes in the total serum protein and the protein fractions following infection with the three strains of *H. contortus* are presented in Figure 54. The values are again expressed as percentages of the preinfection level. The actual data is shown in Appendix 13. In the kids and lambs infected with the LG strain, there was a gradual decline in total protein and albumin values as the infection progressed to day 18. The albumin drop was very insignificant in the kids. The globulin concentration dropped in a similar way in the kids but after day 9 in the lambs, the globulin concentration rose eventually reaching just a little above the preinfection level by day 18. Thus by day 18, the lamb had a higher protein and globulin value and lower albumin value than the kid.

In the lambs infected with the LS strain, there was no appreciable change in total protein, albumin or globulin values during the first 9–12 days post-infection. However, after day 12, the values of these parameters dropped, rather erratically in both host species but with the albumin value remaining higher in the lamb than in the kid while the globulin level was lower than in the latter host.

The animals infected with the ES strain exhibited only a small, insignificant drop in the albumin level throughout the 18 days post-infection. The total protein values fluctuated around the preinfection level, whereas the globulin values were raised above the preinfection level throughout almost all the 18 days.

In all the animals there was a rise in the serum pepsinogen concentration following infection (Figure 55 and Appendix 13). The peak level was reached by day 15 in animals infected with the LG strain, the level being slightly higher in the lamb than in the kid. In animals infected with the LS strain, the concentration rose steeply in the lamb after day 12 while that in the kid dropped. In kids infected with the ES strain, the concentrations rose gradually at first, then steeply after day 12 to a peak by day 15. There was a steep rise only after day 15 in the lamb killed at day 18.

Parasitology

Table 42 gives the number of *H. contortus* of each strain recovered from the abomasal digests and washings of lambs and kids killed at different ages of the parasite. Lambs appeared to harbour higher burdens of the LG

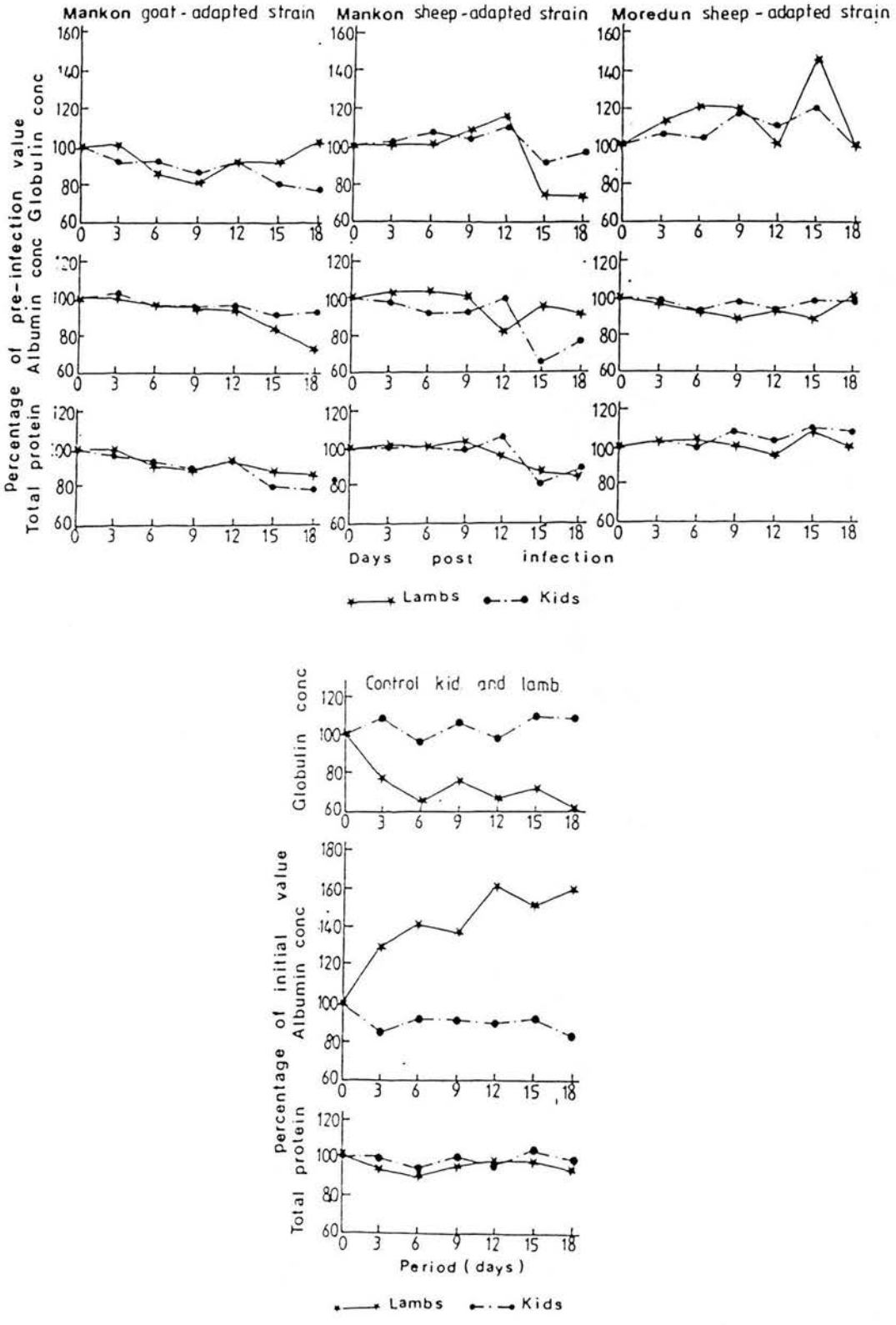


Figure 54 Changes in serum total protein, albumin and globulin concentrations in indigenous lambs and kids infected with a single dose of 10,000 L_3 of three strains of *H. contortus*.

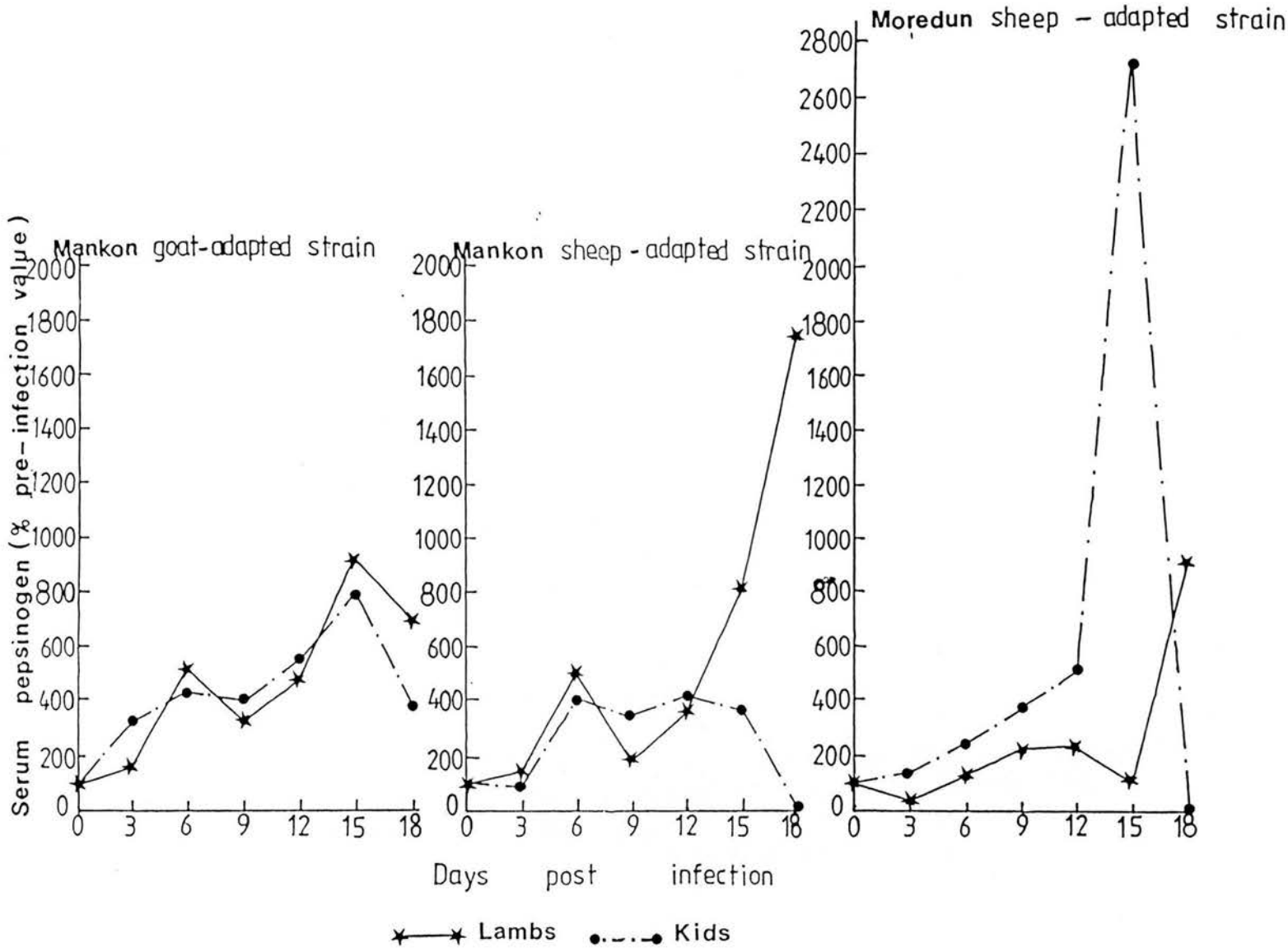


Figure 55 Changes in serum pepsinogen level in indigenous lambs and kids infected with a single dose of 10,000 L_3 of three strains of *H. contortus*.

and ES strain than kids and kids higher burdens of the LS strain than lambs but these differences were not statistically significant.

Table 42 Counts of *H. contortus* recovered from abomasum of local lambs and kids dosed with 10,000 L3 of three strains of the parasite

Age of parasite (days)		Mankon goat-adapted strain		Mankon sheep-adapted strain		Moredun sheep-adapted strain	
		Lambs	Kids	Lambs	Kids	Lambs	Kids
4	Total	202	10	1762	1640	0	0
	Male	1820	2400	750	1050	600	
8	Female	3150	3000	600	2300	700	
	Total	4970	5400	1350	3350	1300	100
	Male			200	3350	100	
11	Female			800	2350	450	
	Total	-	-	1000	5700	550	0
	Male	2322	780	2660	2602	3000	1250
14	Female	3470	614	3270	3408	2850	750
	Total	5792	1394	5390	6010	5850	2000
	Male	2400	600	2260	2250	160	100
18	Female	3600	750	3080	3270	530	380
	Total	6020	1350	5340	5520	690	480

- No animals killed

In both lambs and kids and for all three strains of *H. contortus*, 4th stage larvae were recovered at four and eight days post-infection. At 8 days the worms recovered were in both early and late 4th stage but mainly in the latter. Measurements of worms of the LS strain revealed that the mean length was not significantly different in lambs and kids at four or eight days post-infection (Table 43). Sexual differentiation was apparent from day 8. The female worms in both host species were already significantly ($P < 0.01$) longer than the male worms.

By day 11, the LS strain worms had developed to the 5th larval stage although the remains of the 4th stage shedded cuticle could be seen at the posterior end of most of the worms. The parasites in the lambs were largely free of mucus while those in kids were still coated with mucus and entangled with debris. The size difference of the LS strain female worms in the two host species was very significant ($P < 0.001$), the worms being clearly much bigger in lambs than in kids. Similarly the male worms were significantly larger

($P < 0.05$) in lambs.

Table 43 Growth rate of three strains of *H. contortus* in local lambs and kids

Age of parasite (days)	Length of worm (mm)											
	Mankon goat-adapted strain				Mankon sheep-adapted strain				Moredun sheep-adapted strain			
	Lambs		Kids		Lambs		Kids		Lambs		Kids	
	Male *H.c.*	Female *H.c.*	Male *H.c.*	Female *H.c.*	Male *H.c.*	Female *H.c.*	Male *H.c.*	Female *H.c.*	Male *H.c.*	Female *H.c.*	Male *H.c.*	Female *H.c.*
4	-	-	-	-	1.73		1.73		-	-	-	-
8	-	-	-	-	4.05	5.13	4.05	5.21	-	-	-	-
11	-	-	-	-	8.04	11.18	6.95	8.63	-	-	-	-
14	9.94	12.75	9.63	12.10	10.90	14.31	7.75	9.34	7.00	10.92	3.70	3.07
18	12.32	16.82	7.25	9.11	11.85	15.16	10.08	12.63	11.35	14.25	9.30	11.43

- Insufficient larvae or worms to measure

H.c. = Haemonchus contortus

By day 14, the parasites recovered included both 5th stage and non-gravid adult females and males with fairly well developed bursae. The sex ratio showed the females in excess of the males except in lambs and kids infected with the ES strain and kids infected with the LG strain. A comparison of the three strains of *H. contortus* in sheep and goats at this age revealed very significant differences in size ($P < 0.005$). In kids the LG strain had outgrown the other two strains. The least growth was achieved by the ES strain where the worms were so dwarfed that they were smaller than worms of the LS strain at eight days of age. In lambs on the other hand, the LS strain had outgrown the other two strains, the least growth again being achieved by the ES strain.

By day 18 in lambs, the female *H. contortus* of all three strains measured 14-17 mm long while male worms measured 11-14 mm. The fastest growth was recorded in the LG strain and the least in the exotic strain. Both male and female worms were significantly smaller in kids than in lambs ($P < 0.01$). A reduction in the number of worms from the numbers on day 14 occurred only with the ES strain. Lambs and kids harboured similar burdens of the LS strain while lambs contained larger numbers of worms of the other two strains than kids. The sex

ratio in all the three strains showed an excess of female worms. The *H. contortus* of the LG strain in the kid were smaller than those in the animal killed at 14 days. Gravid females were only observed in the lamb implying that sexual maturity was reached earlier in this host than in the kid. A few strongyle-type eggs (50 epg) were seen in the faeces of the lamb from day 17 but none in the kid's faeces.

Gross Pathology

The changes were similar in each host species for all three strains of *H. contortus*. At four days post-infection, the fundic mucosal surface of the infected lambs and kids showed small circumscribed areas which appeared as slightly raised whitish spots with a central depression possibly associated with oedema. By day 8, a noticeable feature of the abomasal surface of kids infected with the two local strains was the coating of a brown coagulum of clots of denatured blood covering substantial areas of the fundic region. This was not easily washed off. The abomasal surface in lambs showed only congestion with the gastric pits appearing very conspicuous. By day 11, the fundic abomasal surface in kids had circumscribed haemorrhagic areas of clotted blood whereas in lambs the haemorrhage was more spread out, appearing as streaks on the abomasal surface. In both host species, the haemorrhagic area extended from the fundus to the anterior end of the pyloric region. Clots of blood could also be observed in the ingesta. The kids were already showing signs of anaemia with pale abdominal contents.

By day 14, both the lambs and the kids were evidently anaemic. Whereas the abomasal surface of the kids still showed areas of clotted blood, that of the lambs appeared granular with no evidence of blood. By day 18, the abomasal surface in both lambs and kids had a granular appearance with no evidence of blood.

No signs of gastric haemorrhage were observed in any of the ES strain infected animals killed.

Histopathology

The surface of the abomasum of the control lamb and kid had an intact lining with the cells in continuous association with each other (Plate 11). The interstitial tissues of the *lamina propria* contained only very few lymphoid-type cells. Eosinophils were absent. The changes that occurred in the abomasum of lambs and kids following infection with the two local strains of *H. contortus* were essentially similar for each host species.

By four days after challenge, the surface epithelium of the abomasum of the lambs was still intact. No localized cellular responses were observed in either the

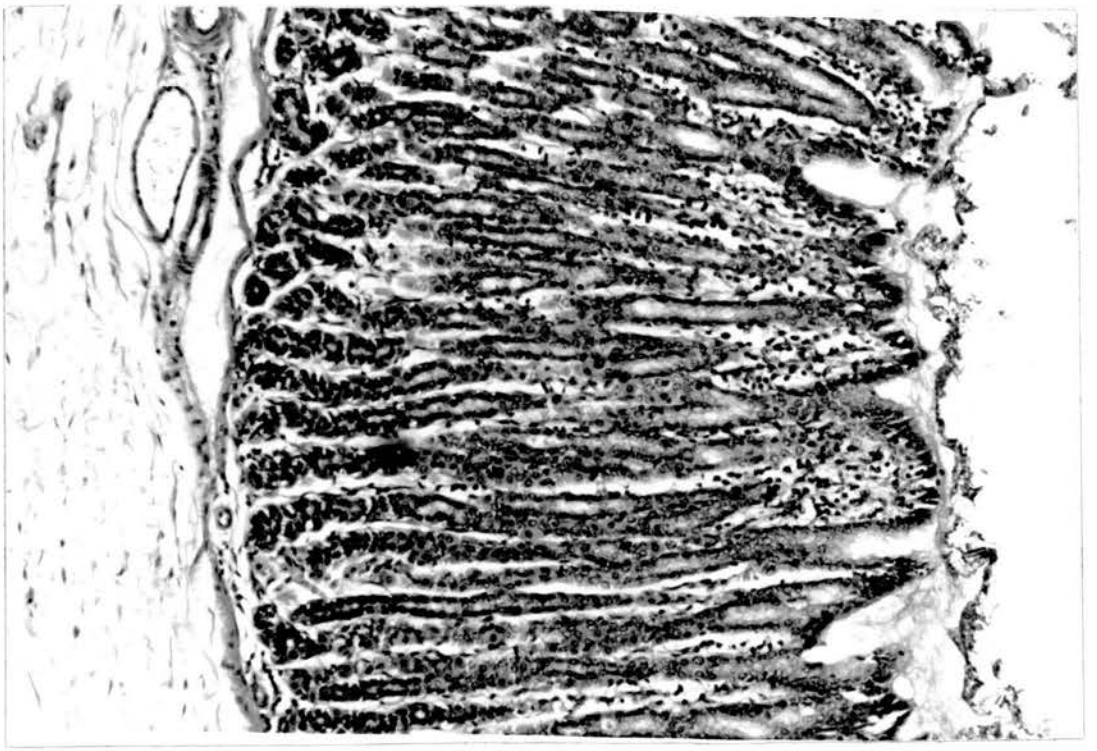


Plate 11a Uninfected lamb

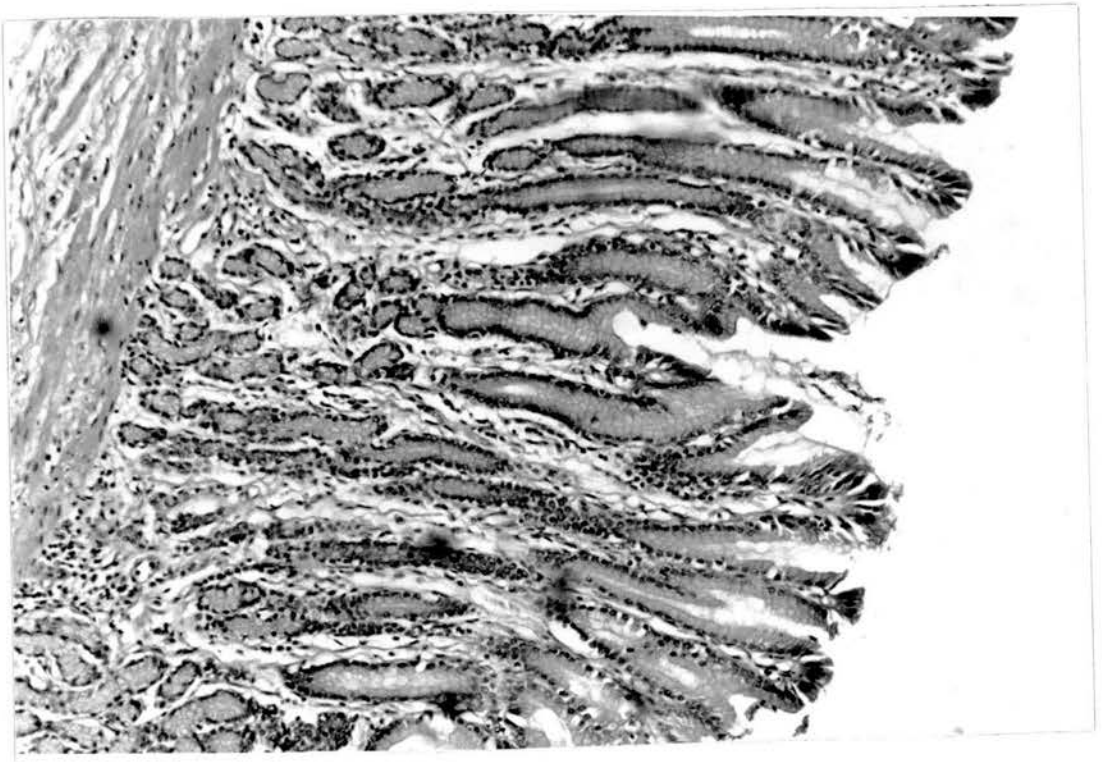


Plate 11b Uninfected kid

Plate 11 Cross section through fundic region of abomasum of an uninfected Grassland Dwarf lamb (a) and kid (b)

submucosa or the *lamina propria*, except for a small collection of eosinophil leucocytes. In the kids the lining epithelium showed indication of disruption in a few places, possibly the locations of the raised white spots observed in the gross examination. There were a few infiltrating mononuclear lymphoid-type cells and very few eosinophil leucocytes in the deep mucosa and submucosa. These initial cellular responses occurred both in the fundic and pyloric portions of the abomasum.

By day 8 (Plate 12) the fundic mucosal epithelium in the lambs appeared less intact with indication of disruption in some places and desquamated cells. A slightly increased number of lymphoid-type cells, eosinophils and plasma cells were observed in the deep mucosal layers. Only a few cells were seen in the submucosa but a cross section through a vein revealed an accumulation of cells, possibly white cells. The pyloric abomasal surface was relatively intact compared to the fundic portion but the cellular reaction was similar to that observed in the fundus although eosinophils and plasma cells were fewer in number. In kids mucosal hypertrophy was beginning to be marked. Cellular responses were the same as observed in the lambs.

By day 11 the parasites were to be observed in the paramucosal space. In the lambs the mucosa was increasingly mutilated with desquamated epithelial cells observed in large numbers in the lumen. Mucous secretion on the epithelial surface had increased. Within the mucosa lymphoid-type cells and eosinophils were easily discernable. In the pyloric portion of the abomasum, the mucous layer was thinner and no parasites were to be seen. In the kids, streaming columns of lymphoid-type cells and a few eosinophils and plasma cells were observed apparently invading the interstitial tissues among the glands. The submucosa in both lambs and kids revealed only a very few cells.

By day 14 (Plate 13), the surface epithelium had been severely mutilated in both lambs and kids and in some areas had come off completely. In lambs nodules and columns of migrating lymphoid-type cells, eosinophils and plasma cells in very dense numbers had invaded both the submucosa and deeper layers of the *lamina propria* in both the fundic and pyloric portions of the mucosa. Goblet cells were secreting mucus at an increasing rate. Sections through the parasite could be seen at both the pyloric and fundic portions of the abomasum. Hypertrophy of the mucosa was now marked. The histopathology in kids at 14 days closely resembled that seen in lambs. Neutrophil polymorphs were numerous with only a few eosinophils.

By day 18 the degeneration of the surface epithelium was still discernable

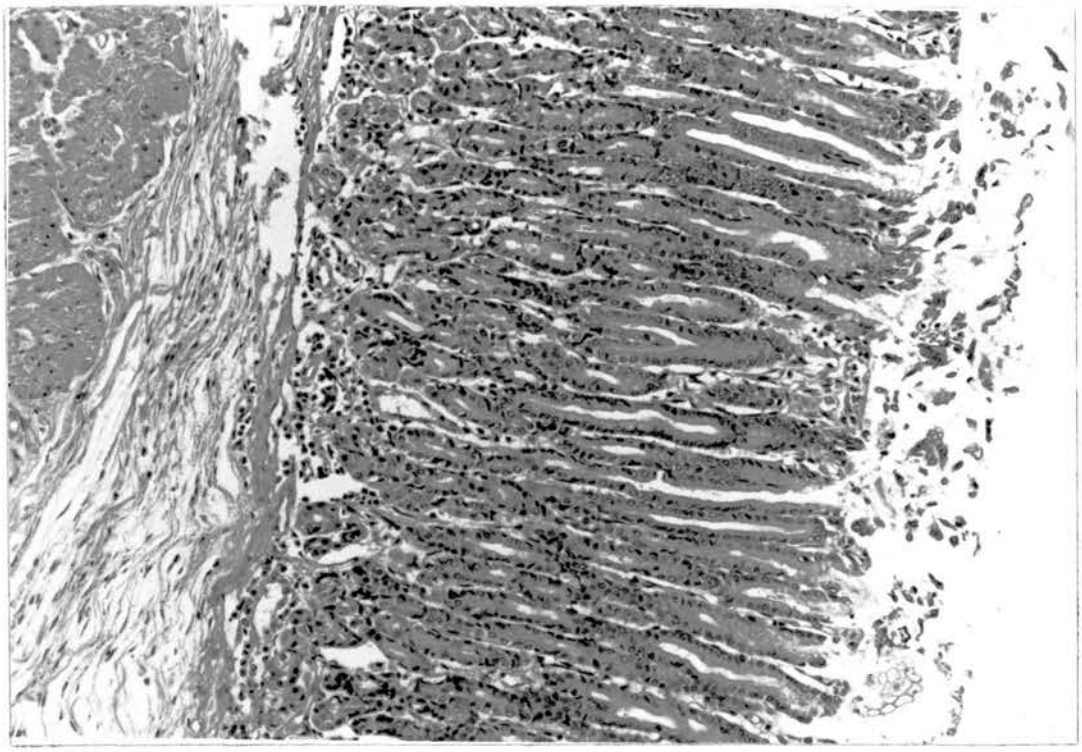


Plate 12a Lamb - 8 day old infection

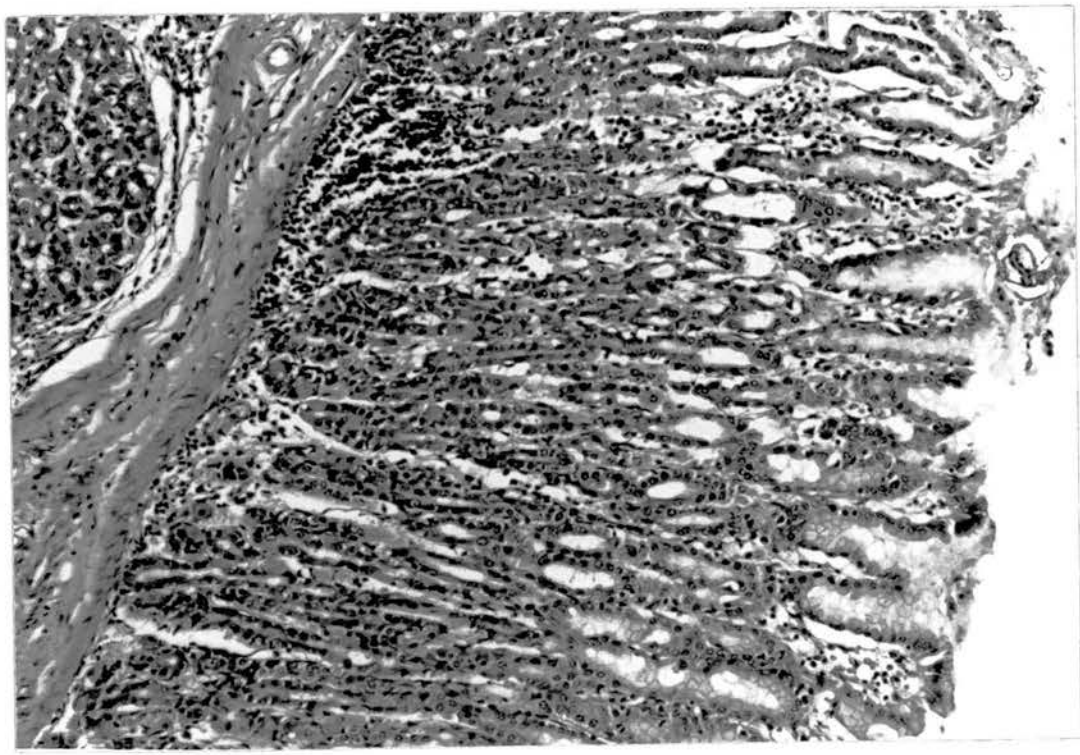


Plate 12b Kid - 8 day old infection

Plate 12 Cross section through fundic region of abomasum of Grassland Dwarf lamb (a) and kid (b) at 8 days post infection with H. contortus (LS strain) showing early stages of cellular responses.

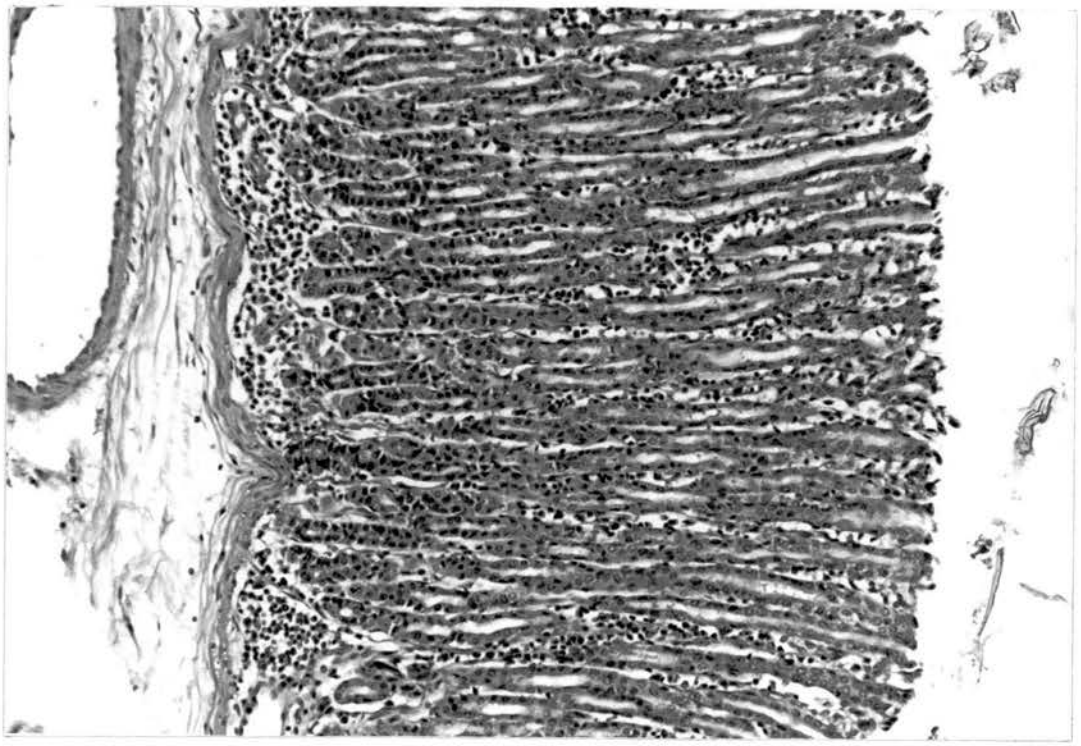


Plate 13a Lamb - 14 day old infection

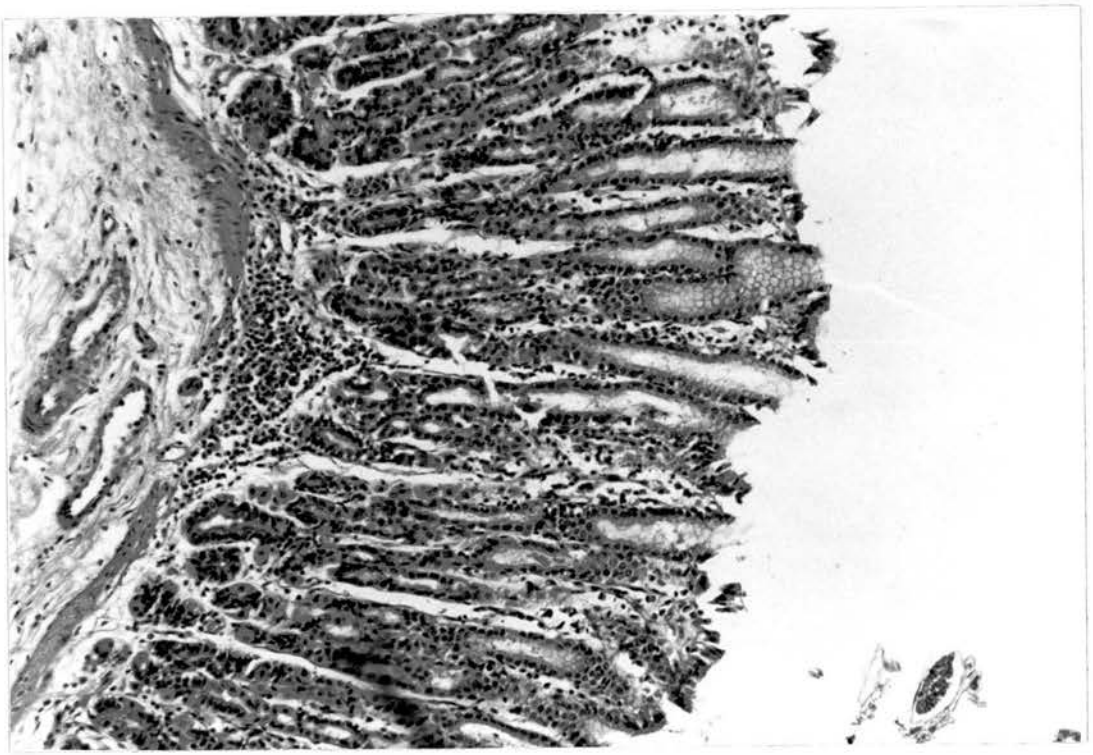


Plate 13b Kid - 14 day old infection

Plate 13 Cross section through fundic region of abomasum of Grassland Dwarf lamb (a) and kid (b) at 14 days post infection with H. contortus (LS strain) showing surface epithelium severely mutilated

but it appeared that the surface was again intact in a few places. In lambs the cellular responses had subsided somewhat, there being fewer lymphoid-type cells, plasma cells and eosinophils than observed earlier. There were fewer plasma cells and eosinophils in the animals infected with the LS than is those infected with the LG strain. In the kids the interstitial cellular response was still quite marked. The migrating cells, mainly lymphoid-type cells, were densely accumulated in the *lamina propria* but eosinophils had decreased greatly in number. Goblet cells were still secreting mucus at an increased rate. In the pyloric portion there were focal areas of large accumulations of cells, mainly lymphoid-type cells. Sections through some of the glands revealed dead cells, a possible indication of glandular damage.

Throughout the course of the infection in all animals, some neutrophil polymorphs were observed but they were never particularly numerous as were the eosinophils.

DISCUSSION

In view of the very few animals used in this experiment, the results obtained and their interpretation, especially the haematological and biochemical changes, should be considered as suggestive and requiring further experimental study to confirm the results, especially as the number of animals on which the measurements were made was being decreased successively by the necropsies performed at 4, 8, 11 and 14 days post-infection. For this same reason statistical analyses could not be carried out on the haematological and biochemical parameters.

The patterns of the haematological changes in indigenous lambs and kids infected with the LG, LS and ES strains of *H. contortus* were in general similar to that seen in the lambs and kids infected with the ES strain at the CTVM. The pattern was essentially similar for all the three strains. However, in contrast to the observations at the CTVM, indigenous kids appeared to have been more severely affected by these infections than lambs in that the haemorrhage was initiated earlier in kids and was more prolonged than in lambs. The greater ability of the lambs of the Grassland Dwarf sheep to resist the ill-effects of larval challenge may be genetically linked, possibly acquired through the natural selection that has occurred in the course of adaptation to their environment and their feeding habits. The existence of a genetically based resistance against *H. contortus* infection has been demonstrated in several investigations including Ackert (1942) and Loggins *et al.* (1965).

Another common feature of the infections in this experiment was

hypoalbuminaemia (Evans *et al.*, 1963; Mulligan *et al.*, 1963). Mulligan and his co-workers observed a reduced albumin half-life and increased loss of radio-iodine labelled polyvinyl pyrollidone into the abomasum of calves infested with *Ostertagia* spp. A similar reduction in the albumin half-life has been recorded in a condition known as "giant gastric mucosal hypertrophy" in man, in which hypoproteinaemia and hypertrophy of the gastric mucosa are seen (Citrin *et al.*, 1957). Charleston (1965) concluded that mucosal hypertrophy and loss of serum protein are related phenomena. The haemorrhage caused by *H. contortus* would also facilitate the loss of serum protein.

Increased mucous production with accompanying hypertrophy of the mucous-secreting cells in the mucosa observed from day 11 is probably in response to the irritation caused by the parasite (Charleston, 1965). Eosinophilic infiltration of the abomasum coincided with an even greater influx of mononuclear cells, chiefly lymphoid-type cells. An influx of eosinophils is most often stimulated by an antigen-antibody reaction (Litt, 1961, 1963; Cohen *et al.*, 1961). Soulsby (1962) suggested that the antigens released during the moult of nematodes are particularly immunogenic. Plasma cells which became noticeable from day 8 are known to produce antibodies. Thus the changes in numbers of eosinophils in the abomasum and the mononuclear cell infiltration of the abomasum, including the lymphoid-type and plasma cells, may be interpreted as evidence for an immune response (Charleston, 1965) directed against the parasitic invasion.

The haematological, biochemical and cellular changes observed in the course of infection all indicated that the severity of the parasitic effects was greater in kids than in lambs and greater in animals infected with the two local strains than in those infected with the ES strain. Surprisingly the kids appeared to be more susceptible to the LS strain than to the LG strain. An indication of resistance by the kids to infection with the LG strain was seen in the greatly retarded growth of the worms after day 14 and in the delay of sexual maturation in the female worms. However, this is more likely a chance reflection of the characteristic of this strain than a real general effect.

The exotic strain did not establish well in either host although it developed comparatively better in lambs than in kids. The relative resistance by both hosts to the ES strain suggests that this strain is in some way different from the local strains and that accordingly the two host species were able to develop and exert a more adverse response to the development and survival of these worms.

ESCALATING INFECTIONS WITH *H. CONTORTUS*

INTRODUCTION

This pilot study was intended to demonstrate the differences in susceptibility of European sheep and goats to *H. contortus* (ES strain) under similar conditions of larval intake and management. It attempts to replicate the epidemiological pattern seen in the field in temperate countries at the end of winter by administering the infective larvae in escalating doses.

EXPERIMENTAL DESIGN

This experiment was conducted at the CTVM and involved six lambs and six kids aged 6–8 weeks reared indoors from birth. There were two experimental groups as follows:-

(i) An infected group comprising four Blackface lambs of Hb type AB and four kids, two Toggenburgs of Hb type B and two Saanens, one of Hb type BC and the other of Hb type B.

(ii) A control group comprising two Blackface lambs (Hb type AB) and two kids, one Toggenburg of Hb type BC and the other Saanen of Hb type BC.

All the kids and lambs used in this study were in good bodily condition prior to experimental infection. Unfortunately one of the kids in the infected group had acquired a light strongyle infection giving 250 eggs per gram of faeces before it was used in the experiment. Similarly four of the lambs, two in the infected group and two in the control group, had light infections of *Strongyloides papillosus* giving 100 epg. They could not be treated since the infections were discovered after the experiment had started.

The animals in the infected group were given escalating doses of the Moredun strain (ES) of *H. contortus* according to the following schedule:-

Week 1	2 x 250 larvae
Week 2	2 x 500 larvae
Week 3	2 x 1000 larvae
Week 4	2 x 2000 larvae
Week 5	2 x 4000 larvae

The larvae were administered on Mondays and Thursdays each week for five weeks.

At the end of eight weeks, all the animals were necropsied and investigated for helminth parasites. Parameters assessed included faecal egg counts carried out twice weekly, liveweight changes, haematology and serum biochemistry determined weekly and worm counts and measurements at necropsy.

RESULTS

Clinical Manifestations

The animals showed few overt signs of infection. One lamb was depressed for a few days 3-4 weeks after initial infection. A kid was anorexic for a short time six weeks after initial infection. Paleness of the conjunctiva and gums became evident as the infection progressed, being more pronounced in the lambs. Diarrhoea was not observed in any of the infected animals which all continued to gain weight until the sixth week when the lambs began to lose weight (Figure 56).

Haematological Observations

The haematological changes are represented in Figures 57 and 58 and Appendix 14 and 15. The preinfection haematological values were similar in the infected and control groups of each species. The anaemia which developed during the course of infection was more severe in the lambs than in the kids, the mean PCV (Figure 57) in the lambs falling by about 46% and that in the kids by about 27% prior to necropsy. The regression slopes for PCV of the infected animals between the 2nd and 8th week of the experiment were significantly different from the controls (lambs: $P < 0.01$, kids: $P < 0.05$).Similar trends were also observed in the RBC counts ($P < 0.001$) (Figure 57) and Hb concentration, the decline in the values of the latter parameter being significant only in lambs ($P < 0.01$). After six weeks of infection the fall in PCV, Hb concentration and RBC counts (Figure 57) tended to stabilise at low levels.

MCV and MCH changed very little during the first four weeks of infection (Figure 58) but then tended to increase up to the seventh week. These changes were more marked in the lambs than in the kids but were not statistically significant in either host. There was no consistent change in the MCHC.

There was no significant difference between the WBC counts in the infected and control animals (Figure 57) although the white cell counts in the infected kids were consistently above those in the controls from week 2 to week 6. The different white blood cell types fluctuated within the normal range with no significant changes from the preinfection values (Appendix 14 and 15).

Biochemical Observations

The changes in the relative concentrations of the total serum protein, albumin and globulin are presented in Figure 59. In neither the lambs nor the kids were there any marked changes in the total serum protein concentration during the first four weeks of infection. A comparison of the regression slopes for infected and control groups between the fourth week and the termination of the experiment at eight weeks reveals that the mean total protein in the lambs dropped significantly ($P < 0.05$). The total protein in the kid varied little over this

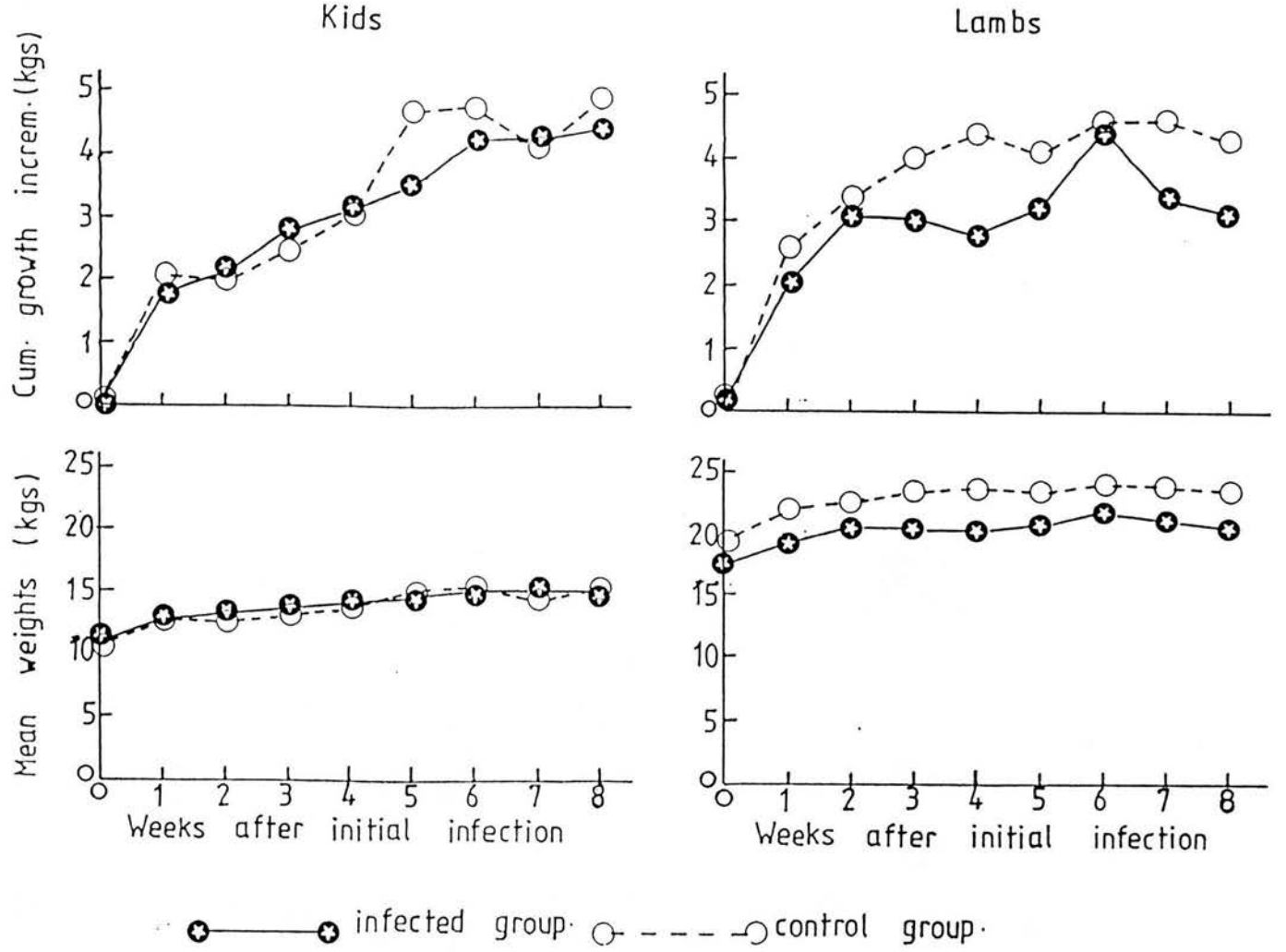


Figure 56 Mean weekly weights of European lambs and kids infected with escalating doses of *H. contortus* (ES strain).

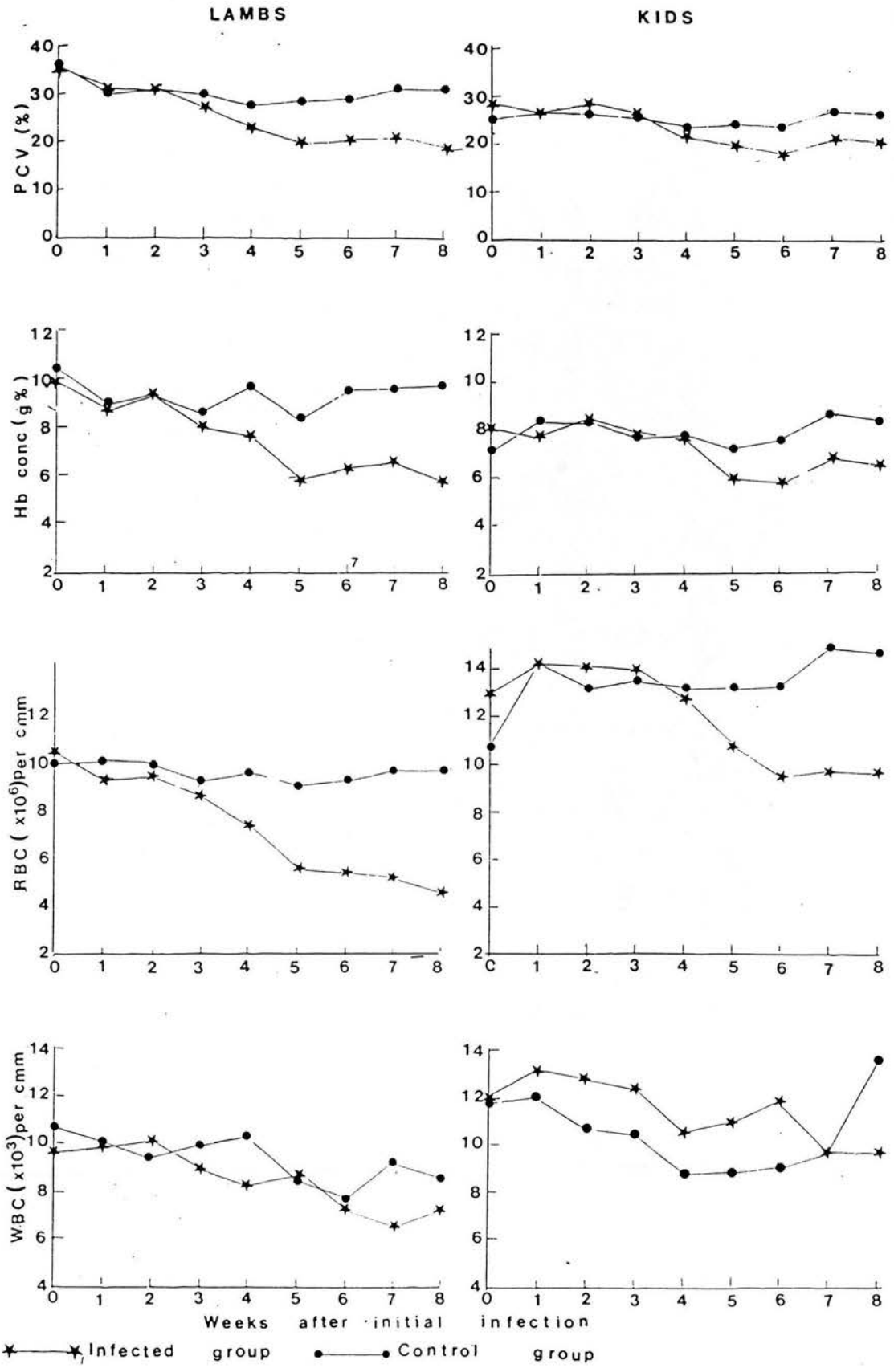


Figure 57 Haematological changes in European lambs and kids infected with escalating doses of *H. contortus* (ES strain).

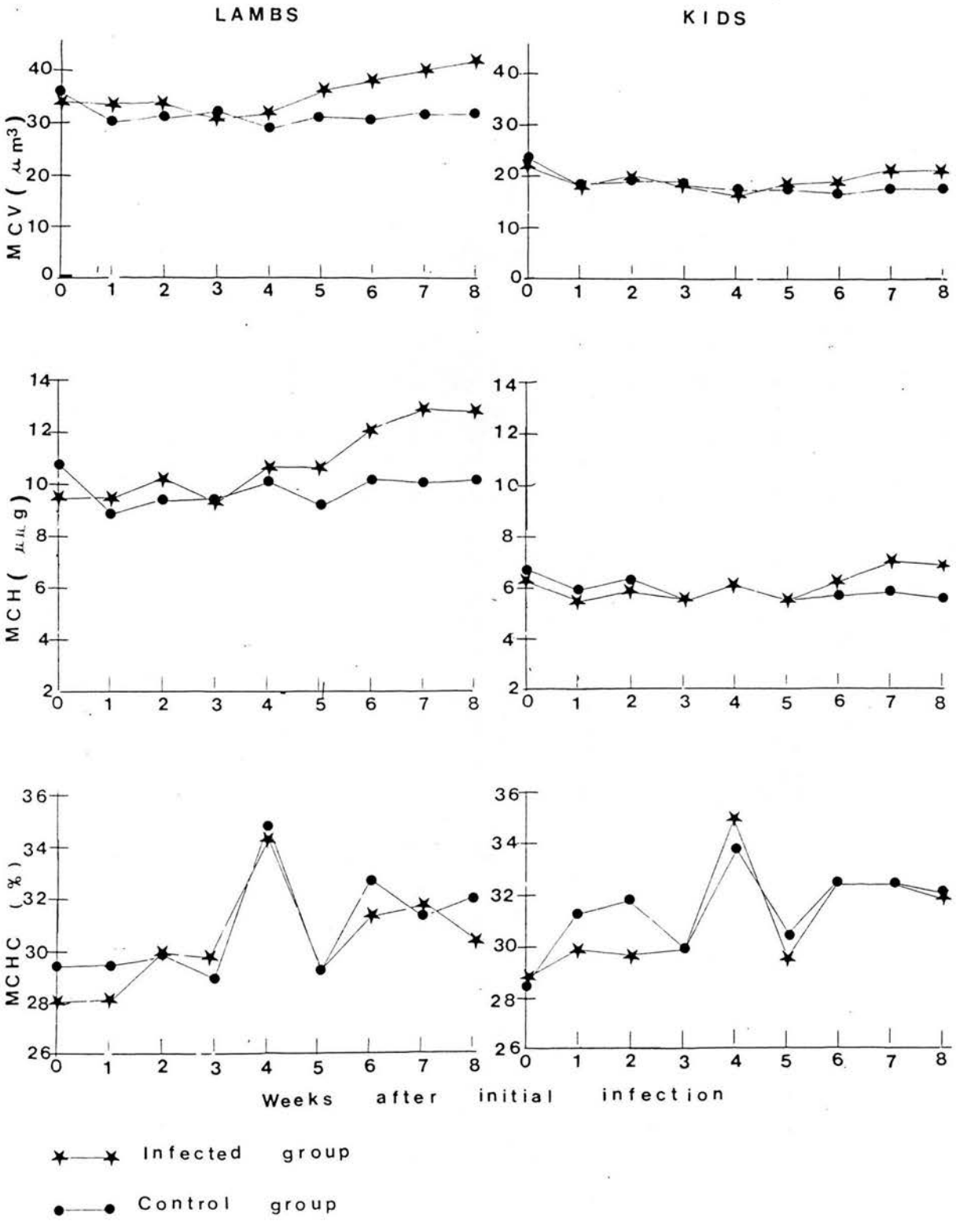


Figure 58 Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) of European kids and lambs infected with escalating doses of *H. contortus* (ES strain).

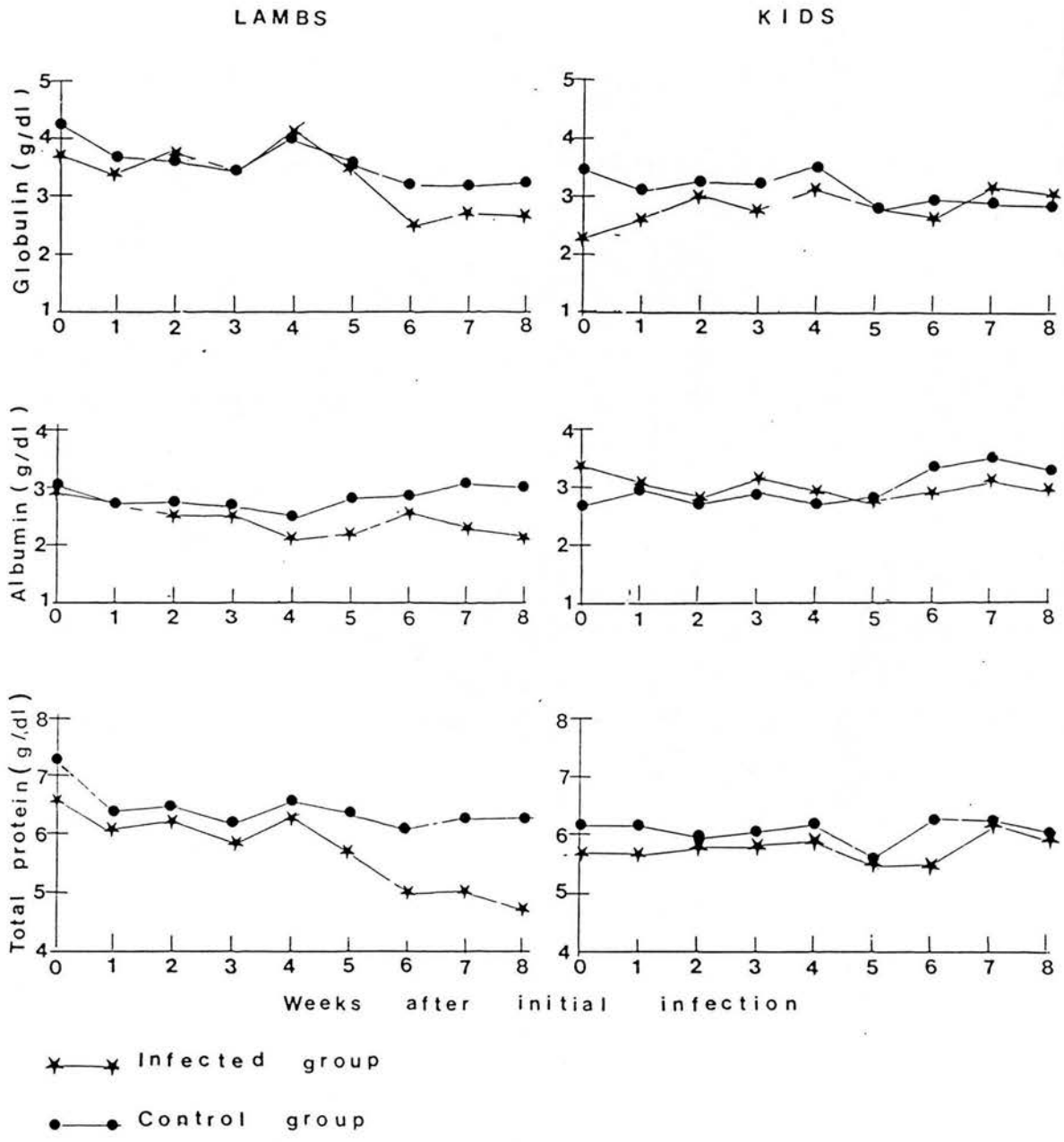


Figure 59 Mean serum protein changes in European kids and lambs infected with escalating doses of *H. contortus* (ES strain).

period, the difference between the two hosts being highly significant ($P < 0.02$).

The concentration of serum albumin gradually fell more in the infected lambs than in the infected kids during the first four weeks after which it more or less stabilised, the fall over the whole eight weeks being significant ($P < 0.02$). This fraction showed little change in the kids. The globulin fraction in both hosts rose slightly during the first four weeks but then fell in the lambs while remaining relatively stable in the kids. However none of these changes were significant.

The serum pepsinogen concentration (Figure 60) in the kids showed a progressive rise being above the normal values by three weeks and reaching a peak at four weeks. In the lambs there was a slower and less consistent rise to a lower peak at four weeks. The concentration in the infected kids was generally higher than that in the infected lambs throughout the experiment. The correlation between adult worms at necropsy and peak serum pepsinogen concentration was negative but not significant in kids ($r = -0.77$, $P > 0.05$).

Parasitological Observations

The mean faecal egg counts from both hosts are shown in Figure 61. By day 18 all the lambs were passing eggs but it was not until day 21 that all the kids were also passing eggs. Thereafter the egg output increased dramatically, more rapidly in the lambs than in the kids, the difference being significant by day 31 ($P < 0.05$). The regression lines for egg counts between 2–5 weeks were highly significant in both hosts (lambs: $P < 0.001$; kids: $P < 0.002$). In the lambs the counts continued to rise until the end of the experiment while in the kids they fluctuated around the same level from day 38.

Necropsy

At necropsy about 60 days after infection, the abdominal contents of the lambs were pale and they had moderate amounts of ascitic and pericardial fluids. The abdominal contents of the kids were only faintly pale and they had little or no ascitic fluid but moderate quantities of pericardial fluid. The lambs contained 3789± 508 and the kids 2084±717 adult *H. contortus* ($P < 0.01$). No immature forms were observed. In both hosts the mucosal surface had a granular appearance but petechiations were observed in the pyloric region of one kid. Small numbers of *Strongyloides papillosus* and *Trichuris ovis* were found in some of the lambs. A control kid had one *Skrjabinema ovis* in its colon and 19 *Trichuris ovis*, while an infected kid contained 20 *Nematodirus* spp., 80 *Ostertagia* spp. and 4 *Trichuris ovis*.

The correlation between the final worm count and the peak faecal egg count was positive but not significant in both lambs ($r = 0.38$) and kids ($r = 0.46$). The mean faecal egg production per female worm at peak egg production was not

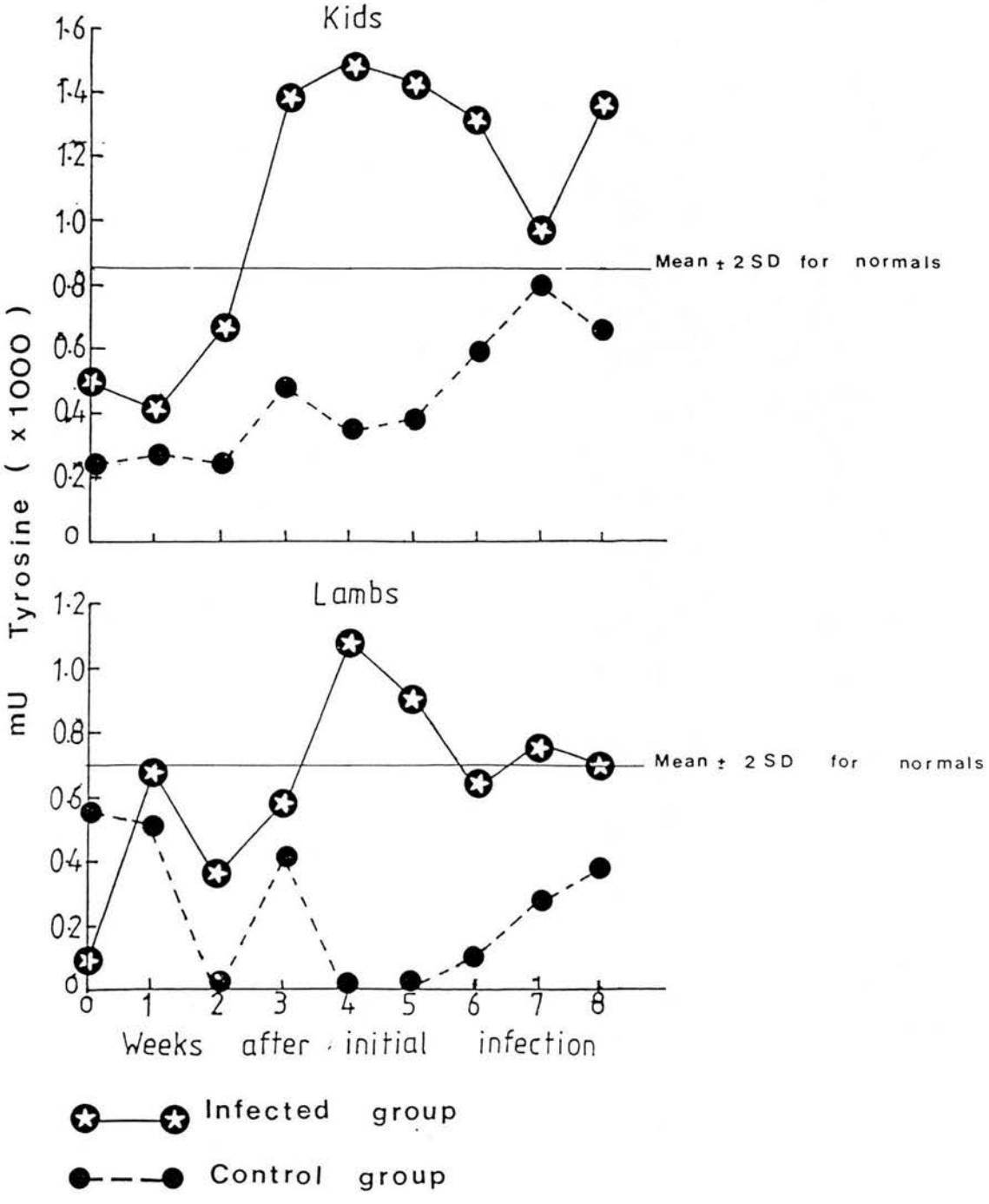


Figure 60 Mean serum pepsinogen concentration of European lambs and kids infected with escalating doses of *H. contortus* (ES strain).

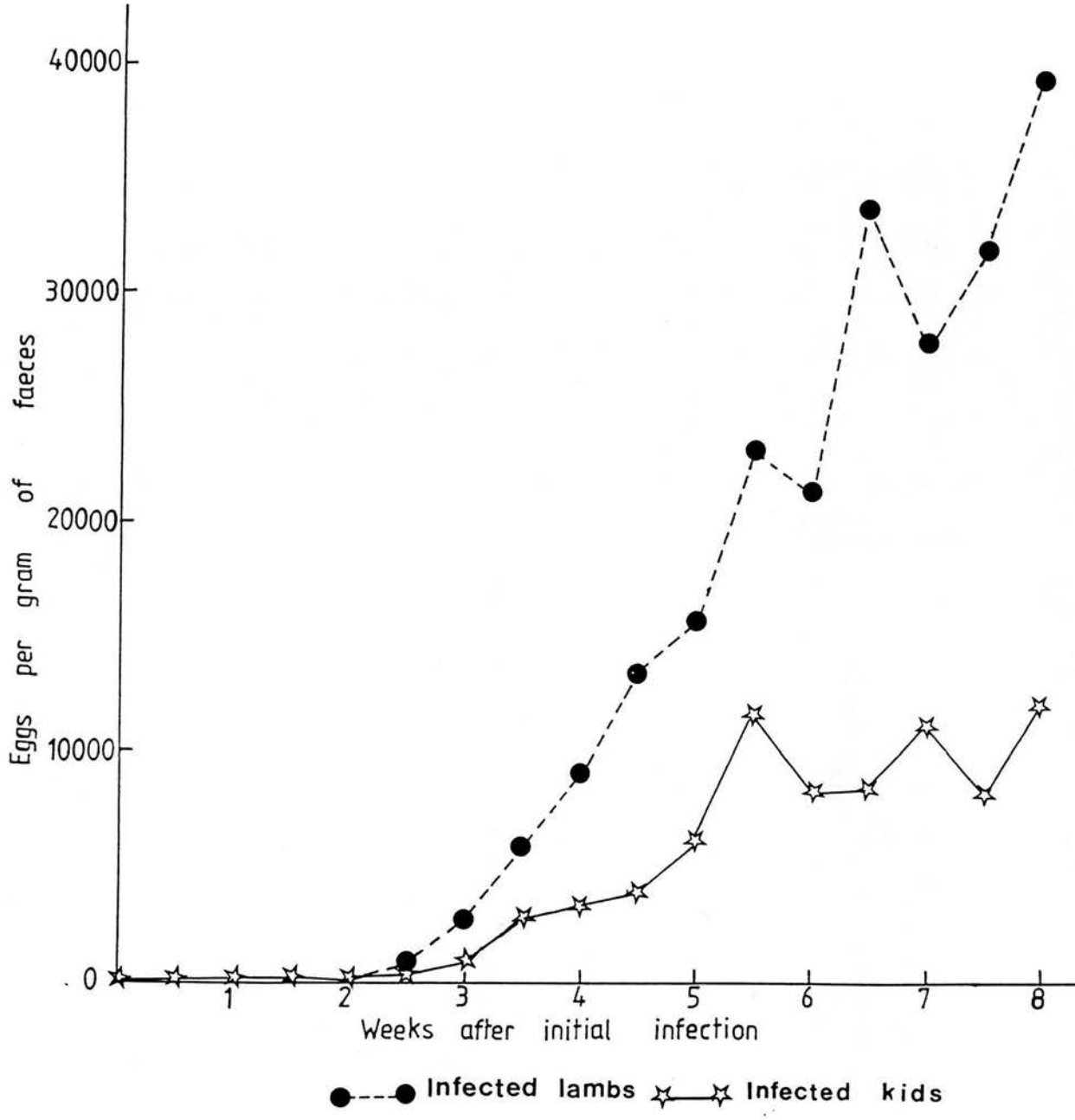


Figure 61 Mean faecal egg counts of European lambs and kids infected with escalating doses of *H. contortus* (ES strain).

significantly different in kids and lambs.

The female worms from the lambs were significantly longer and less variable in length (23.4±1.9 mm) than those from the kids (21.1±2.6 mm) ($P < 0.02$). The male worms were similar in length in both hosts (15.8±.9 and 15.8±1.1 mm respectively). The parasite sex ratio was 1.1:1 (female:male) in the kids and 1.2:1 in the lambs.

DISCUSSION

The nematode infections acquired by some of the animals before the experiment began were probably too light to have had any significant effect on the parameters measured as indicated by the results on haematology and serum biochemistry in the controls.

The virtual lack of clinical signs in the animals was probably a reflection of the relatively good diet. Otherwise the pathological changes in the lambs were similar to those described by previous workers (McIntosh, 1944; Misra and Ruprah, 1972; Soulsby, 1982) and will not be discussed in detail. Those observed in the kids were generally qualitatively similar but it was clear that the Moredun strain of *H. contortus*, which had been maintained in sheep, was more pathogenic in sheep than in goats. This conforms with the report of McCulloch and Kasimbala (1970).

More definite indications of parasitism were shown by the haematological changes since *H. contortus* is known to be haematophagic (Misra and Ruprah, 1972). Anaemia which was the main sign of haemonchosis in the infected animals in this study has long been recognised as the outstanding pathogenic effect of *H. contortus* infection and is a direct result of haemorrhage caused by the damage done by the worms to the mucous membranes of the abomasum (Fourie, 1931; Andrews, 1942).

The preinfection haematological values agree with those given by Oduye (1976), Santos Matos *et al.* (1982) and Doxey (1983). The observed decrease in PCV and Hb concentration along with erythropenia following *Haemonchus* infection agree with the reports of Misra and Ruprah (1972), Pradhan and Johnstone (1972), Zajicek (1973), Anosa (1977), Al-Khshali and Altaif (1979) and Bezubik *et al.* (1980). Fourie (1931) remarked that a progressive decrease in RBC count occurs when the bone marrow can no longer fully meet the enormous demands made upon it. The more severe anaemia in the lambs reflected the fact that they harboured significantly more adult worms than the kids. Christie *et al.* (1964) observed that the decline in haematocrit levels is proportional to the adult worm population.

A considerable fall in both total serum protein and albumin was recorded in the lambs. Al-Khshali and Altaif (1979) also noted a progressive reduction in total

serum proteins and albumin in Awassi and Merino sheep from three weeks after a primary infection with *H. contortus*. Work by several other investigators confirms the decrease in total serum protein and albumin following experimental infection (Raisinghani *et al.*, 1971; Shastry and Ahluwalia, 1972; Kerboeuf, 1977; Uppal and Rai, 1978). Uppal and Rai (1978) attributed the hypoproteinaemia to interference with digestion and absorption by damage caused to the abomasal mucosa by the parasites coupled with the effects on the pH and enzyme activity therein. This conclusion confirms the findings of Endrejat (1956), Leland *et al.* (1959) and Kuttler and Marble (1960). The fall in total serum protein and serum albumin in lambs is characteristic of haemonchosis (Soulsby, 1982). The total protein concentration in kids tended to be slightly elevated while the changes in albumin concentration were insignificant. When Raisinghani *et al.* (1971) observed a similar slight increase in total serum protein in one group of their experimental animals, they attributed this to either host resistance or to a variation in the strain of the parasite. Similarly it appears that these kids were able to mount a more effective resistance against the establishment of this strain of *H. contortus* than were the lambs.

The serum globulin concentrations in the infected animals were not markedly different from the controls. The general trend was for the concentrations in kids to rise and those in lambs to fall after an initial slight rise, but neither of these changes was significant. Kerboeuf (1977) recorded a decrease in total globulin level following a single experimental infection with *H. contortus*. Al-Khshali and Altaif (1979) did not notice any significant changes in serum globulin levels during the course of the infection; Shastry and Ahluwalia (1972) recorded an increase following experimental infection in goats; Raisinghani *et al.* (1971) reported an increase in gamma globulin in lambs he dosed with 10,000 and 20,000 *H. contortus* larvae but noted a fall on the 40th day in the group he dosed with 5,000 larvae. He attributed the fall to resistance developing at that dose level. Such variations in results obtained by different investigators reflect that it is all a matter of balance between production - possibly increased production - and loss, which occurs independently for albumin and globulin.

The period of sudden increase in serum pepsinogen concentration from the second week of infection coincided with the time when the first batch of larvae were approaching sexual maturity in the host and matches with the time of rapid decline in PCV. Thomas and Waller (1975) found in *ostertagiasis* that serum pepsinogen concentration is directly related to abomasal damage and is a much earlier indication of the degree of worm build up than faecal egg count. Kerboeuf (1980) demonstrated a direct relationship between the number of worms in the

abomasum of naturally infected sheep and the serum pepsinogen concentration. However, in the kids in the present study, there was a negative but insignificant correlation between *H. contortus* count and the peak serum pepsinogen concentration and the concentration of this enzyme was higher in the kids than in the lambs, even though the latter harboured more parasites. The negative correlation (which was nearly significantly so) between adult worms at necropsy and peak serum pepsinogen concentration in the kids suggests that although the goats were poorer hosts for the worms and developed lighter infections, it looks as though their abomasal mucosa was just as badly damaged by the larvae, hence the similarity between sheep and goats during (say) the first four weeks but divergence afterwards when the adult worms in the sheep began to affect them.

Worm eggs were first detected in the faeces 18 days after infection, although oviposition may have started earlier as the previous faecal examination was carried out three days before. Silverman and Patterson (1960) reported that in susceptible lambs eggs are first produced 12–15 days after infection, while in older susceptible sheep development is delayed and eggs are first produced after 16–24 days. Since the animals in the present experiment were being dosed at 3 and 4 day intervals alternately, it can be deduced that until resistance supervened, a new batch of sexually mature worms would be produced every 3–4 days commencing about 18 days after initial infection.

Both lambs and kids received the same larval doses administered in exactly the same manner yet there were clear differences in the worm burdens and faecal egg production, with the lambs having significantly more worms, a shorter prepatent period and higher faecal egg counts than the kids. The larvae administered from about 3 weeks after the infection began did not appear to cause any later increase in the egg output in the kids. This all suggests a greater level of resistance in the kids. Radhakrishnan *et al.* (1972), Altaif and Dargie (1978) and Preston and Allonby (1978, 1979b) recorded similar differences in responses between breeds of sheep and goats infected with *H. contortus*. They considered these differences to indicate the presence of inherited factors operating against infection with *H. contortus* in resistant breeds. However, it should be noted that the Scottish Blackface are themselves a relatively resistant breed (Altaif and Dargie, 1978).

In conclusion this study has demonstrated that differences exist between lambs and kids in the haematological, biochemical and parasitological changes induced by infection with escalating doses of *H. contortus* infective larvae. It is suggested that these differences were due to this particular strain of *H. contortus*

being more infective and pathogenic in sheep than in kids, to the kids being immunologically more competent at developing resistance to the infection administered in this manner or to a combination of both these factors. Similar studies were conducted using the field strains of *H. contortus* in an area of the Republic of Cameroon where both hosts were naturally infected. However, this time, the infections were given in small daily doses seven times weekly as discussed below.

PROLONGED EXPOSURE TO DAILY INFECTIONS WITH *H. CONTORTUS*

INTRODUCTION

This study was aimed at examining the effect on sheep and goats of exposure to infective larvae of *H. contortus* (LG and LS strains) over a prolonged period when larvae are administered in small doses daily. The experiment simulated the field situation where animals are grazing on lightly contaminated pastures over an extended period.

EXPERIMENTAL DESIGN

The experiment was conducted in Mankon and involved nine lambs (Grassland Dwarfs) and nine kids (six Red Sokotos and three Grassland Dwarfs) aged 6–8 months which had been reared indoors from birth. The distribution of the experimental animals by treatment and their respective haemoglobin types are shown in Table 44. The animals were infected seven times weekly at daily intervals with 200 *H. contortus* larvae of the appropriate strain for 20 weeks. At the end of this period, all the animals were necropsied and investigated for helminth parasites.

Table 44 Distribution of experimental animals on daily infections with two strains of *H. contortus*

Experimental group (strain of *H. contortus*)	Animals involved and Hb type		
	Sheep	Goats	
	Grassland Dwarf	Red Sokoto	Grassland Dwarf
Mankon goat-adapted strain	3 (All Hb B)	2 (All Hb B)	1 (Hb B)
Mankon sheep-adapted strain	3 (2 Hb B, 1 Hb AB)	2 (1 Hb B, 1 Hb BC)	1 (Hb B)
Control	3 (All Hb B)	2 (Both Hb BC)	1 (Hb BC)

Parameters measured at weekly intervals included liveweight changes, faecal egg counts, haematology and serum biochemistry.

RESULTS

The weight changes in lambs and kids during the period of the experiment are summarised in Table 45 and Appendix 16. Weight gains in kids were depressed for at least one month from the start of initial infection before the animals again consistently gained weight (Table 45) whereas in lambs such an initial depression in weight gain did not occur. The final weight gains in the two groups of kids were similar and lower than in the lambs. Overall, the final weight

gains in the infected lambs were comparable to those in the control whereas the caprine controls gained significantly ($P < 0.05$) more weight than the infected kids.

Table 45 Weight changes in lambs and kids infected with 200 L3 daily doses of two strains of *H. contortus* at Mankon, Cameroon

Experimental group	Mean weight changes (kg)						Wt. gain (kg) over 20 week period
	Initial weight	4 wks	8 wks	12 wks	16 wks	20 wks	
LS strain infected group:-							
Lambs	10.2	10.8	11.4	11.9	12.0	13.2	3.0±2.1
Kids	6.1	6.1	6.4	6.7	6.9	7.1	1.0±0.1
LG strain infected group:-							
Lambs	9.1	9.8	10.5	10.8	11.1	12.1	3.0±1.1
Kids	6.5	6.5	6.9	6.7	6.9	7.2	0.7±0.1
Uninfected controls							
Lambs	10.7	11.1	11.6	12.3	12.5	13.1	2.4±0.7
Kids	7.1	7.2	7.4	8.0	8.0	8.7	1.6±0.4

The first peak count in faecal egg output was reached within the first six weeks from commencement of infection (Figure 62). The pattern of weekly faecal egg counts reveals that most of the higher counts in the kids were in animals infected with the LG strain while in lambs it was the LS strain that gave rise to the highest counts. Throughout the 20 weeks of infection, most animals had low egg counts (< 500 epg) for most of the time. However, there was no significant difference in egg counts between lambs and kids receiving daily doses of the same strain of *Haemonchus*.

Necropsy worm counts showed that kids carried higher burdens of the LG strain and lower burdens of the LS strain than lambs (Table 46). The counts in all of them were generally low, less than 600 adult worms, and the sex ratio showed an excess of female worms. Overall the animals infected with the LS strain had higher counts than those infected with the LG strain but the difference was not significant.

The haematological picture clearly indicates that in all the infections, kids were generally more severly affected than lambs (Appendix 17). The pattern over

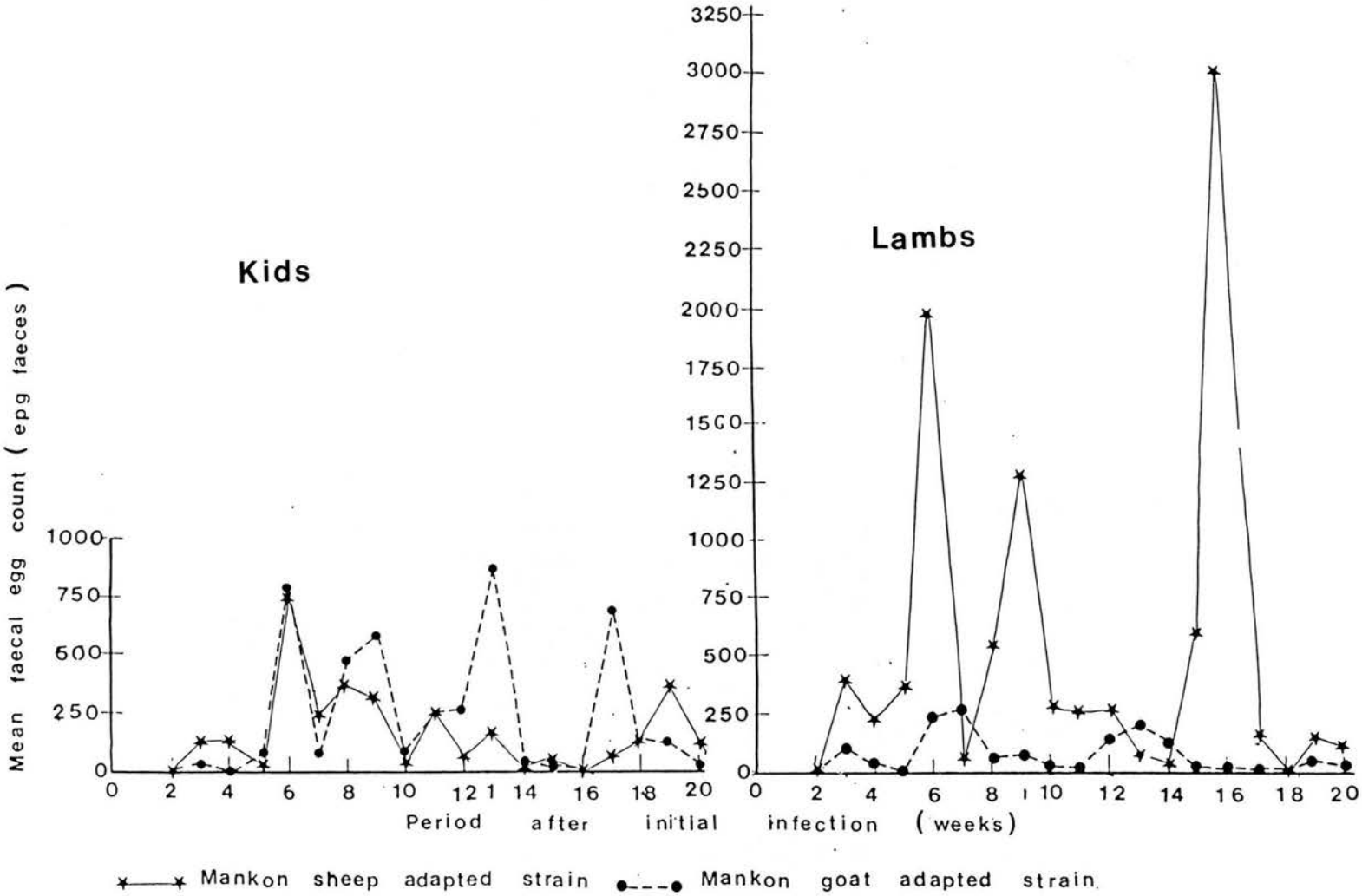


Figure 62 Faecal egg counts of indigenous lambs and kids on daily infections with 200 infective larvae of two strains (LG and LS) of *H. contortus* at Mankon, Cameroon.

the entire 20 week period is one of prolonged depression in PCV, Hb concentration and RBC values in kids infected with both strains of *H. contortus* in contrast to the controls. The PCV and RBC values were more depressed in the kids receiving the LS strain than in those receiving the LG strain (PCV: $P < 0.02$, RBC: $P < 0.01$). In contrast the values of these three parameters in lambs fluctuated within the range of the preinfection values. The white blood cells fluctuated in no particular pattern.

Table 46 Necropsy worm counts at 20 weeks in lambs and kids infected with 200 L_3 daily doses of two strains of *H. contortus* at Mankon, Cameroon.

Experimental group	Necropsy worm counts		Sex ratio
	Mean	Range	
LS strain infected group			
Lambs	572	275–1040	1.9:1
Kids	418	250–585	2.0:1
LG strain infected group			
Lambs	205	120–250	1.9:1
Kids	498	325–670	1.8:1

The concentration of the serum protein and protein fractions fluctuated within the range of the preinfection values (Appendix 17) and were comparable to the values in the control. The serum pepsinogen level increased during the course of the infection, especially from the second week (Appendix 18). Overall, the values were higher in kids than in lambs, but this difference was significant ($P < 0.01$) only in animals infected with the LG strain. There was no parasite strain distinction in the pattern of the serum pepsinogen level.

DISCUSSION

The growth of the lambs was not affected by the infections whereas there was a considerable reduction in that of the kids compared to the control. This goes to confirm the observations from the epidemiological studies that indigenous sheep were able to resist helminth larval challenge more effectively than goats and agreed with the reports of Soulsby (1982) and Pomroy *et al.* (1986)

The patterns of faecal egg counts also largely reflect the degree of susceptibility of the two host species to the two strains of *H. contortus*. Each strain appeared to survive best in its host of origin. At the same time the rather low egg counts throughout most of the 20 weeks of the experiment may well be an indication of early developed and sustained host resistance. The low worm

counts at necropsy of the experimental animals after 20 weeks of daily exposure to infections is a further indication of resistance.

Development of resistance to helminth infections under conditions of continuous infection has been demonstrated by several investigators. Dineen *et al.* (1965) observed that with daily doses of 100 larvae of *H. contortus* those given after day 10 failed to develop beyond the 4th stage and that delayed development was more marked following continuous daily doses of 100 larvae than after one dose of 3,000 larvae. Gibson and Parfitt (1973) observed that 11–16 week old lambs given daily doses of 2,000 infective larvae of *T. colubriformis* developed resistance against the infection during the first 30 weeks of life. Christie *et al.* (1978) infected lambs with daily doses of 10,000 infective larvae of *H. contortus* and found at the end of six months that all seven sheep had acquired a high degree of resistance. Pradhan and Johnstone (1972), on the other hand, observed that exposure of weaned lambs to 500 3rd stage infective *H. contortus* larvae per day was more pathogenic than when the same total weekly number of larvae was given in one dose at weekly intervals.

It can be deduced from these studies, including the present study, that if animals on pasture are to be protected from the harmful effects of haemonchosis some minimal exposure to larval challenge from an early age, reinforced by repeated contact in adult life, is desirable to enable the animals to develop and maintain resistance. Such acquired resistance would then enable the animals to destroy a large percentage of their larval intake. This is the view put forward by Taylor (1962).

The haematological parameters were more depressed in kids than in lambs. Since *H. contortus* is a blood sucking parasite, continuous exposure to infection will inevitably cause a slow continuous loss of blood from the animals. However, the depression of the haematological values comes about not only as a result of the blood sucking activity of the worms but also through the haemorrhage which appeared from the single-infection studies to occur between the 8th and 14th day of larval development within the host. Since the animals in the present experiment were on daily challenge, the haemorrhage will have been more or less continuous from soon after initial infection until resistance developed. The ability of the lambs to withstand this continuous exposure to challenge better than kids may indicate that sheep have evolved more effective resistance mechanisms against these common gastrointestinal nematodes (Soulsby, 1982).

The biochemical parameters were similarly affected by these infections but not to the same degree as the haematology. The serum pepsinogen concentration

was generally increased and provides a useful indication of the abomasal damage.

It may thus be concluded from this study that Grassland Dwarf sheep appear to have a greater ability to withstand haemonchosis than Grassland Dwarf goats. Since this observation does not hold for all breeds of sheep and goats, it would appear that the differences observed in susceptibility are related to the particular breed of the animal. Preston and Allonby (1978) stated that differences in susceptibility are due to the relative ability of the breeds to elicit an immune response against the parasite. However, the present study has shown that the lambs did not necessarily become more resistant but clearly showed greater tolerance to larval challenge than kids. Indeed both hosts ultimately developed a high degree of resistance to the infections as evidenced from the low worm counts.

PART V

GENERAL DISCUSSION

Under natural conditions animals carry a mixed infection of various species of nematodes each of which has a different epidemiological pattern. The main environmental factors determining the seasonal availability of the infective stages of these helminths and hence the prevalence of the associated diseases are climatic, especially temperature and rainfall.

The weather pattern in the North West Province of Cameroon appears to be relatively constant for any particular area from year to year, thus making possible more precise predictions about the effects of the weather. Examples of this predictability include the demarcation of the two main seasons, the driest month, the peak periods of monthly total rainfall, the months during which minimum temperatures go below 15°C, etc. This consistency allows a better opportunity to relate weather patterns to the occurrence of helminth infections and thus facilitate the development of a model for predicting the probable time of an outbreak of parasitic gastroenteritis.

Studies of temperature effects on development of the free-living stages of *H. contortus* and *O. circumcincta* revealed *inter alia* that the minimum temperature at which infective larvae of *H. contortus* can be reached is 11°C. This is well below the average minimum temperature (15°C) for the Bamenda area implying that temperature is not a limiting factor in the preparasitic development of this parasite in that area. Rather it is rainfall which determines the availability and transmission of strongyle nematode larvae of all species. However, as was clear from the studies using tracer animals or pasture larval counts, the dry season in this area is insufficiently intense or prolonged to prevent the animals being effectively under continuous challenge from infective larvae of various strongyle parasites and occasionally they are exposed to sudden heavy challenges such as might be encountered on highly contaminated pastures used for rotational grazing or at the peak of pasture larval contamination in the rainy season.

The productivity data obtained in this study clearly indicate that goats do better under village conditions than under the present farm (research station) conditions, whereas with sheep the opposite is the case. The main reason for this is probably that given by ILCA (1979), Soulsby (1982) and Schillhorn van Veen (1982) who suggested that the browsing behaviour of

goats, which reduces their chances of acquiring pasture-transmitted parasite infections, may have resulted in their failure, as a breed, to evolve an effective defence mechanism against the ill-effects of the common gastrointestinal nematodes of ruminants as have sheep. This situation was reflected in the experimental infection studies in which lambs and kids were exposed to small daily doses of infective larvae of *H. contortus*. The rather low egg counts in both hosts throughout most of the 20 weeks of that experiment in addition to the low worm counts at necropsy were probably indications of early developed and sustained host resistance. However, the haematology and serum biochemistry revealed that these animals, and especially the kids, do nevertheless suffer from the effects of the parasitism. The PCV and Hb concentration were depressed in goats but not in sheep, again suggesting that the sheep are more capable of tolerating the effects of larval challenge than the goats. Furthermore the growth of the lambs was not affected by the infections whereas there was retardation of normal growth in the kids. However, although sheep can effectively resist moderate larval challenge, they do succumb under conditions of heavy infections and/or multifactorial stress such as occurs under village management. Indeed their greater growth potential may well be a disadvantage under these conditions.

Although the further experimental studies at Mankon and at the CTVM involving single and escalating infections with *H. contortus* can only be regarded as indicative because of the small number of animals available, they appear to suggest that the differences observed in susceptibility of sheep and goats to haemonchosis are probably related to the particular breed of the animal and the strain of the parasite and therefore do not necessarily hold for all sheep and goats. The single experimental infections at Mankon revealed that the primary haematological parameters were more depressed in indigenous kids than in lambs infected with the local strains of *H. contortus*. However, when the animals were infected with the ES strain these parameters were slightly more depressed in lambs than in kids. This observation with the ES strain confirms the results of the experimental studies at the CTVM where this strain was administered to small numbers of European lambs and kids both as a single primary infection and in escalating doses. In these infections at the CTVM, the lambs appeared to suffer from the infection more than the kids. The lambs had significantly more worms, a shorter prepatent period and higher faecal egg counts, suggesting that the ES strain was better adapted to develop and survive in lambs than in kids.

A comparison of the effects of the three strains of *H. contortus* (LG, LS, ES) on indigenous sheep and goats in Bamenda revealed that the pathogenicity was greater in kids than in lambs and in animals infected with the two local strains than in those infected with the European ES strain. There did not appear to be any significant difference in the response of the two host species to infection with the two local strains. The ES strain had been maintained exclusively in sheep for many generations whereas, although the LS strain was immediately obtained from sheep and the LG strain from goats, both of these were previously derived from a common pool of pasture larvae. It appears that the local strain is more or less equally infective for both sheep and goats, and in particular, that it does not consist of a mixture of two sub-strains, one more infective for sheep and the other for goats. Thus on the whole these experimental studies confirmed the differences between the hosts observed in the epidemiological studies.

The high mortality in the goats at Mankon during the second year of the epidemiological studies may have been largely caused by helminthiasis but the effects of helminth infections were probably exacerbated by *Oestrus ovis* larvae infestation, which may have rendered the animals more susceptible to the effects of the helminths through lowering of their resistance. This exemplifies the multifactorial nature of the disease situation in the field and the difficulty of isolating the effects of a single infection. In itself the importance of *O. ovis* infection in small ruminants in the area requires study. For example the use of Ivermectin to simultaneously eliminate both the worms and the three instars of *O. ovis* larvae merits consideration including a suitably controlled investigation.

Haemonchus contortus and *Trichostrongylus* spp. are the most frequent species of helminths, occurring throughout the year but with higher burdens during the rainy season. *Oesophagostomum columbianum* and *Bunostomum trigonocephalum* become important during the rainy season from July onwards. *Trichuris ovis* and *Cooperia curticei* are also more prevalent in the rainy season. *M. expansa* may occur at any time of the year. The common broad spectrum anthelmintics are effective against all these nematode species but will usually not eliminate the tapeworms. However, the latter occur in such insignificant numbers that they can be considered to be of little pathological importance.

Contamination of the pastures with infective larvae is greatly reduced during the dry season and both faecal egg and pasture larval counts are low

during this period so that the infectivity rate is minimal. Peak periods of larval availability on pasture are in mid-June and towards the end of the rains in November. Between the peaks the numbers of larvae on the herbage may be reduced by run-off from the heavy rains. Outbreaks of parasitic gastroenteritis can thus be anticipated between July and September and again in the early part of the dry season. The effects of the parasitism during the early part of the dry season will be exacerbated by the increasing nutritional stress on the animals during this period.

Benzimidazole resistance by the trichostrongyles in the animals at Mankon was confirmed by comparing the *in vitro* benzimidazole susceptibility of the strongyle-type eggs from the animals at Mankon with those obtained from village animals that had never been treated with anthelmintics. Although neither of the strains showed *in vitro* susceptibility to fenbendazole, the eggs from the animals at Mankon consistently developed in higher concentrations of tiabendazole than did the eggs from the village animals.

Despite the problems caused by anthelmintic resistance it is clear that strategic treatments of the animals can modify the magnitude and timing of the peak periods of availability of larvae on pastures, making effective and cost-effective control possible. Thus in the animals on the 2-dose anthelmintic regime, the first peak was reached in May and the second in September. For those on the 4-dose anthelmintic regime, the first peak was reached in May/June and the second in August. It would appear that if a single effective treatment was to be given in or a little before the driest month, it would be possible to eliminate or at least markedly delay the build up of the first peak of pasture contamination, thereby making the two schedule treatments of the 2-dose regime in May and July even more effective in reducing the infections in the animals and so reducing the further contamination of the pastures and the resulting larval challenge throughout the rest of the rainy season.

The haematological and serum biochemical parameters of the animals on pasture have been shown to be affected by both seasonal variations in the helminth burden and the nutritional status of the animal. The primary haematological parameters and the total serum protein and albumin are generally low during the dry season and become raised in the early rainy season. However, they may later again be lowered at various times during the rainy season, probably mainly depending on the extent of damage to the abomasum and small intestine by *Haemonchus* and *Trichostrongylus*

colubriformis respectively. The results from the chronic experimental infection studies suggest that the depression of the haematological values comes about not only as a result of the blood sucking activity of *Haemonchus* but also through haemorrhage, which appeared from the single-infection studies to occur between the 8th and 14th day of larval development within the host. Since the animals on pasture are under continuous challenge, such haemorrhage may be occurring in both lambs and kids more or less continuously from soon after initial infection until resistance is developed. Extensive haemorrhage of this type will, however, be rare in older animals except when they are exposed to heavy larval challenge.

The globulin concentration and hence the total protein concentration normally increase when the albumin concentration is lowered and vice versa. The serum pepsinogen concentration is generally raised during the rainy season, which is probably also an indication of abomasal damage. The fluctuations in the concentration of these biochemical parameters will occur in response to helminth infections. This observation was confirmed by the experimental infection studies.

Although no helminthological advantage will be gained by grazing sheep and goats together, it would appear from the point of view of pasture utilization, especially under village conditions where browse and grass are abundantly available, that maximum utilization of the available food can be obtained by keeping sheep and goats together because of their different nutritional preferences. Effective control of helminth infections can probably be achieved at Mankon by a set-stocking grazing system and three strategic anthelmintic treatments given in December-January, May and July. The dry season treatment might preferably be Ivermectin so eliminating both any residual worm burden and *Oestrus ovis* larvae. This would reinforce the natural partial decontamination of the pastures provided by the dry season and ensure that animals are not so quickly exposed to heavy infections when favourable conditions for development of larvae return with the onset of the rains. The May and July treatments will control infestation rates during the peak periods of pasture larval availability and keep the worm burdens relatively low till the dry season when the December-January treatment is again given. Pastures should be changed every year, preferably just before the onset of the rains. Since benzimidazole resistance has been demonstrated at the research station the use of a single anthelmintic continuously and frequently is clearly hazardous. Village flocks could with advantage receive the same regime but

this must be accompanied by changes in husbandry to be fully effective. If tethering is utilized as a management system, animals and especially kids should always be tethered where there is ample browse to avoid exposing them to heavy pasture contamination. Adequate feeding, especially in the dry season, is highly desirable and perhaps even essential for sheep to avoid malnutrition and its interaction with parasitism.

REFERENCES

Ackert, J.E. (1942). Natural resistance to helminthic infections. Journal of Parasitology, **28**: 1-24.

Adams, H.R., Boyd, E.M., Wilson, J.B., Miller, A. and Huisman, T.H.J. (1968). The structure of goat haemoglobins. III. Haemoglobin D, a β chain variant with one apparent amino acid substitution (21 Asp-His). Archives of Biochemistry and Biophysics, **127**: 298-405.

Adams, H.R., Wrightstone, R.N., Miller, A. and Huisman, T.H.J. (1969). Quantification of haemoglobin α chains in adult and foetal goats; gene duplication and the production of polypeptide chains. Archives of Biochemistry and Biophysics, **132**: 223-236.

Adeoye, S.A.O. (1985). Disease profiles of sheep and goats in two groups of villages in South West Nigeria. In Sumberg and Cassaday (Eds.): Sheep and goats in humid West Africa. Proceedings of the workshop on small ruminant production systems in the humid zone of West Africa, held in Ibadan, Nigeria, 23-26 January, 1984. p.13-16.

Akerejola, O.O., Schillhorn van Veen, T.W. and Njoku, C.O. (1979). Ovine and caprine diseases in Nigeria, a review of economic losses. Bulletin of Animal Health and Production in Africa, **27**: 65-70.

Al-Khshali, M.N. and Altaif, K.I. (1979). The response of Awassi and Merino sheep to primary infection with *Haemonchus contortus*. Tropical Animal Health and Production, **11**: 164-170.

Allonby, E.W. and Urquhart, G.M. (1973). Self cure of *Haemonchus contortus* infections under field conditions. Parasitology, **66**: 43-53.

Allonby, E.W. and Urquhart, G.M. (1976). A possible relationship between haemonchosis and haemoglobin polymorphism in Merino sheep in Kenya. Research in Veterinary Science, **20**: 212-214.

Altaif, K.I. and Dargie, J.D. (1978). Genetic resistance to helminths - the influence of breed and haemoglobin type on the response of sheep to primary infections with *Haemonchus contortus*. Parasitology, **77**: 161-185.

Anderson, F.L. and Levine, N.D. (1968). Effect of desiccation on survival of the free-living stages of *Trichostrongylus colubriformis*. Journal of Parasitology, **54**: 117-128.

Anderson, F.L. and Christofferson, P.V. (1973). Efficacy of haloxan and thiabendazole against gastrointestinal nematodes in sheep and goats in the Edwards Plateau area of Texas. American Journal of Veterinary Research, **34**: 1395-1398.

Anderson, N. (1972). Trichostrongylid infections of sheep in a winter rainfall region. I. Epizootiological studies in the Western district of Victoria, 1966-67. Australian Journal of Agricultural Research, **23**: 1113-1129.

Anderson, N. (1973). Trichostrongylid infections of sheep in a winter rainfall region. II. Epizootiological studies in the Western district of Victoria, 1967-68. Australian Journal of Agricultural Research, **24**: 599-611.

Anderson, N., Armour, J., Jarrett, W.F.H., Jenning, F.W., Ritchie, J.S.D. and Urquhart, G.M. (1965). A field study of parasitic gastritis in cattle. Veterinary Record, **77**: 1196.

Andrews, J.S. (1942). Stomach worm (*Haemonchus contortus*) infection in lambs and its relation to gastric haemorrhage and general pathology. Journal of Agricultural Science, **65**: 1-18.

Anosa, V.O. (1977). Haematological observation in helminthiasis caused by *Haemonchus contortus* in Nigerian Dwarf sheep. Tropical Animal Health and Production, **9**: 11-17.

Anosa, V.O. and Isoun, T.T. (1976). Serum proteins, blood and plasma volumes in experimental Trypanosoma vivax infections of sheep and goats. Tropical Animal Health and Production, **8**: 14-19.

Armour, J. (1980). The epidemiology of helminth disease in farm animals. Veterinary Parasitology, **6**: 7-46.

Assoku, R.K.G. (1981). Studies of parasitic helminths of sheep and goats in Ghana. Bulletin of Animal Health and Production in Africa, **29**: 1-10.

Bain, M.S. (1986). Determination of albumin in caprine serum. Research in Veterinary Science, **41**: 82-84.

Barbancho, M., Llanes, D., Morera, L., Garzon, R. and Rodero, A. (1984). Genetic markers in the blood of Spanish goat breeds. Animal Blood Groups and Biochemical Genetics, **15**: 207-212.

Barger, I.A., Benyon, P.R. and Southcott, W.H. (1972). Simulation of parasite larval populations of *Haemonchus contortus*. Proceedings of the Australian Society of Animal Production, **9**: 38-42.

Barger, I.A. and Southcott, W.H. (1975). Control of nematode parasites by grazing management. I. Decontamination of cattle pastures by grazing with sheep. International Journal of Parasitology, **5**: 39-44.

Barrow, D.B. (1964). The epidemiology of nematode parasites of sheep in the border area. Onderstepoort Journal of Veterinary Research, **31**(2): 151-162.

Baruah, P. and Bhat, P.P. (1980). Note on the genetics of haemoglobin and transferrin polymorphism in three breeds of Indian goats. Indian Journal of Animal Science, **50**(7): 576-579.

Bawden, R.J. (1969). Relationships between *Oesophagostomum columbianum* infection and the nutritional status of sheep. III. Serum and tissue protein changes. Australian Journal of Agricultural Research, **20**: 965-970.

Bawden, R.J. (1976). The organization of parasitological research into field problems. Abstracts of papers, Annual General Meeting, Australian Society for Parasitology, May 17-18, p.17.

Becklund, W.W. (1964). Helminths of **ruminants**: geographical distribution and economic importance. Proceedings of the United States Livestock Sanitation Association 67th Assembly meeting 1963, 523-532.

Belle, E.A. (1959). The effect of microenvironment on the free-living stages of *Bunostomum trigonocephalum*. Canadian Journal of Zoology, **37**(3): 289-298.

Berberian, J.F. and Mizelle, J.D. (1957). Development studies on *Haemonchus contortus* Rudolphi (1803). American Midland Naturalist, **57**: 421-439.

Bezubik, B., Byszewska-szpocinski, E. and Stankiewicz, M. (1980). Immunological studies on experimental haemonchosis in sheep. II. Haematological observations after single infections. Parasitologica Polonica, **29**: 29-45, 391-398.

Bhat, P.P. (1986). Genetic markers in Jumunapari and Sirohi goat breeds. Indian Journal of Animal Science, **56**(4): 430-433.

Blunt, M.H. (1965). Changes in type of haemoglobin during experimental haemorrhagic anaemia in sheep. American Journal of Physiology, **209**: 986-990.

Blunt, M.H. and Evans, J.V. (1963). Changes in the concentration of potassium in the erythrocytes and in haemoglobin type in Merino sheep under severe anaemic stress. Nature, London, **200**: 1215.

Boag, B. and Thomas, R.J. (1971). Epidemiological studies on gastrointestinal nematode parasites of sheep. I. Infection patterns on clean and autumn-contaminated pasture. Research in Veterinary Science, **12**: 132-139.

Braend, M., Efremov, G. and Helle, O. (1964). Abnormal haemoglobin in sheep. Nature, London, **204**: 700.

Brunsdon, R.V. (1965). Internal parasites and sheep production. Proceedings of the Ruakura Farmers' Conference, pp. 43-57.

Brunsdon, R.V. (1966). Internal parasites of sheep and their effects on production. Proceedings of the New Zealand Society of Animal Production, **26**: 165-179.

Brunsdon, R.V. (1970). Within-flock variations in strongyle worm infections in **sheep**: the need for adequate diagnostic samples. New Zealand Veterinary Journal, **18**: 185-188.

Brunsdon, R.V. (1972). The potential role of pasture management in the control of trichostrongyle worm infection in calves with observations on the diagnostic value of plasma pepsinogen determination. New Zealand Veterinary **Journal,20**: 214-220.

Brunsdon, R.V. (1980). Principles of helminth control. Veterinary Parasitology, **6**: 185-215.

Brunsdon, R.V. and Vlassoff, A. (1971). The post-parturient **rise**: a comparison of the pattern and relative generic composition of strongyle egg output from lactating and non-lactating ewes. New Zealand Veterinary Journal, **19**(1-2): 19-25.

Bryan, R.P. (1972). The effects of dung beetle activity on the numbers of parasitic gastrointestinal helminth larvae recovered from pasture samples. Australian Journal of Agricultural Rsearch, **24**: 161-168.

Buckley, J.J.C. (1940). Observations on the vertical migrations of infective larvae of certain bursate Nematodes. Journal of Helminthology, **18**(4): 173-182.

Buvanendran, V., Sooriyamoorthy, T., Ogunsusi, R.A. and Adu, I.F. (1981). Haemoglobin polymorphism and resistance to helminths in Red Sokoto goats. Tropical Animal Health and Production, **13**: 217-221.

Cabannes, R. and Seran, C. (1955). Etude lectrophortigue des hmoglobines des Mammifres domestiques. D'Algerie Comptes rendus de la Socit de Biologie, **149**: 1193-1197.

Cabaret, J. and Planchenault, D. (1986). [Factors influencing the haematocrit and erythrocyte count in the Zaian sheep breed of Moroco] Facteurs de variation de l'hemocrite et du nombre de globules rouges chez la race ovine Zaian du Moroc. Acta Cientifica Venezolona, **37**(1): 79-82.

Cameron, C.D.T. and Gibbs, H.C. (1966). Effects of stocking rate and flock management on internal parasitism in lambs. Canadian Journal of Animal Science, **46**: 121-124.

Cameron, T.W.M. (1923). On the biology of the infective larvae of Monodontus trigonocephalus (Rud) of sheep. Journal of Helminthology, **1**(5): 205-214.

Cameron, T.W.M. (1956), Parasites and parasitism. Wiley, N.Y.

Charleston, W.A.G. (1965). Pathogenesis of experimental haemonchosis in sheep, with special reference to the development of resistance. Journal of Comparative Pathology, **75**: 55-67.

Chiejina, S.N. (1986). The epizootiology and control of parasitic gastroenteritis of domesticated ruminants in Nigeria. Helminthological Abstracts (Series A), **55**(11): 413-429.

Chiejina, S.N. and Emehelu, C.O. (1986). Evaluation of three strategic anthelmintic programmes for the prophylaxis of parasitic gastroenteritis in cattle in eastern Nigeria. Tropical Animal Health and Production, **18**: 55-63.

Chiejina, S.N. and Fakae, B.B. (1984). Development and survival of gastrointestinal nematode parasites of cattle on pasture in Eastern Nigeria. Research in Veterinary Science, **37**: 148-153.

Christie, M.G., Brambell, M.R. and Charleston, W.A.G. (1964). Worm populations in young sheep dosed daily with 10,000 larvae of *Haemonchus contortus*. Journal of Comparative Pathology, **4**: 435-446.

Christie, M.G., Hart, R., Angus, K.W., Devoy, J. and Patterson, J.C. (1978). Resistance of *Haemonchus contortus* in sheep given repeated daily doses of 10,000 infective larvae. Journal of Comparative Pathology, **88**(2): 157-165.

Christie, M. and Jackson, F. (1982). Specific identification of strongyle eggs in small samples of sheep faeces. Research in Veterinary Science, **32**: 113-117.

Ciorda, H., Bizell, W.E., Baird, D.M., McCampbell, A.C. and White, P.E. (1964). Effect of rotational grazing systems on gastrointestinal nematodes in beef yearlings. American Journal of Veterinary Science, **28**: 1473-1478.

Citrin, Y., Sterling, K. and Halsted, J.A. (1957). The mechanism of hypoproteinemia associated with giant hypertrophy of the gastric mucosa. New England Journal of Medicine, **257**: 906-912.

Clark, D.T. (1966). Control of *Haemonchus contortus* in sheep on pasture. Michigan State University Veterinarian, **26**(3): 115-118.

Clarke, E.A. (1963). The economic importance of intestinal parasites. New Zealand Veterinary Journal, **11**(4): 77-81.

Clarke, E.A. and Filmer, D.B. (1958). Studies in hogget rearing. II. The role of parasites in hogget ill-thrift. New Zealand Journal of Agricultural Research, **1**: 382-417.

Clunies Ross, I. (1932). Observations on the resistance of sheep to infestation by the stomach worm (*Haemonchus contortus*). Journal of the Council for Scientific and Industrial Research, **5**(2): 73-80.

Coadwell, W.J. and Ward, P.F.V. (1975). Observations on the development of *Haemonchus contortus* in young sheep given a single infection. Parasitology, **75**: 505-515.

Cohen, S.G., Kantor, M. and Gatto, L. (1961). Experimental eosinophilia. II. Regional lymph node responses to reactions of tissue sensitization. Journal of Allergy, **32**: 214-222.

Coles, G.C. and Simpkin, K.G. (1977). Resistance of nematode eggs to ovicidal activity of benzimidazoles. Research in Veterinary Science, **22**: 386-387.

Connan, R.M. (1968a). The post-parturient rise in faecal nematode egg count of ewes; its aetiology and epidemiological significance. World Review on Animal Production, **4**: 53-57.

Connan, R.M. (1968b). Studies on the worm populations in the alimentary tract of breeding ewes. Journal of Helminthology, **42**: 9-28.

Connan, R.M. (1971). The seasonal incidence of inhibition of development in *Haemonchus contortus*. Research in Veterinary Science, **12**: 272-274.

Connan, R.M. (1972). The effect of host lactation on a second infection of Nippostrongylus brasiliensis in rats. Parasitology, **64**: 229-233.

Conway, D.P. (1964). Some effects of temperature on the development and activity of *Haemonchus contortus* larvae. Cornell Veterinarian, **54**(2): 266-270.

Conway, D.P. and Whitlock, J.H. (1964). A study of the variables influencing artificial infections with *Haemonchus contortus*. Cornell Veterinarian, **54**: 19-54.

Crofton, H.D. (1948). Ecology of immature phases of trichostrongyle nematodes. I. The vertical distribution of infective larvae of *Trichostrongylus* retortaeformis in relation to their habitat. Parasitology, **39**: 17–38.

Crofton, H.D. (1954). Nematode parasite populations in sheep in lowland farms. I. Worm counts in ewes. Parasitology, **44**: 465–677.

Crofton, H.D. (1958). Nematode parasite populations in sheep on lowland farms. V. Further observations on the post-parturient rise and a discussion on its significance. Parasitology, **48**: 243–250.

Crofton, H.D. (1963). Nematode parasite populations in sheep on pasture. Technical Communication 35 of Commonwealth Bureau of Helminthology, St. Albans. Commonwealth Agricultural Bureau, England. 104 pp.

Crofton, H.D. (1965). Ecology and biological plasticity of sheep nematodes. I. The effect of temperature on the hatching of eggs of some nematode parasites of sheep. Cornell Veterinarian, **55**: 242–250.

Crottaz, M. (1975). Etude des groupes sanguins et des systmes proteiniques polymorphisme biochemique chez la chèvre Saanen et la chèvre Alpine Chamoise. Thse inaugurale. Institut de Zootechnie de l'Universit de Berne.

Dacie, J.V. and Lewis, S.M. (1966). Practical Haematology. J. & A. Churchill Ltd., 104 Gloucester Place, London.

Dakkak, A., Robin, B. and Kachani, M. (1986). [Efficacy of Ivermectin in treating parasitic bronchopneumonia, gastrointestinal helminthoses and *Oestrus ovis* infestation in sheep.] Efficacit de l'Ivermectin dans le traitement des bronchopneumonies, vermineuses des strongyloses digestive et de l'Oestrose de mouton. Revue de Mdecine Vtrinaire, **137**(11): 781–787.

Dargie, J.D. and Allonby, E.W. (1975). Pathophysiology of single and challenge infections of *Haemonchus contortus* in Merino sheep; studies on red cell kinetics and the "self cure" phenomenon. International Journal of Parasitology, **5**: 147–157.

Devendra, C. (1976). Small ruminant production in various regions of the world. Proceedings of the workshop on the role of sheep and goats in agricultural development, Winrock Rep., Mirrotton, A.K.

Devendra, C. (1981). Potential of sheep and goats in less developed countries. Journal of Animal Science, **51**(2): 461–473.

Devendra, C. and McLeroy, G.B. (1982). Goat and sheep production in the tropics. Longman, London.

Dinaburg, A.G. (1944). Development and survival under outdoor conditions of eggs and larvae of the common ruminant stomach worm, *Haemonchus contortus*. Journal of Agricultural Research, **69**: 421-433.

Dineen, J.K., Donald, A.D., Wagland, B.M. and Offner, J. (1965). The dynamics of the host-parasite relationship. III. The response of sheep to primary infection with *Haemonchus contortus*. Parasitology, **55**: 515-525.

Dobson, C. (1967). Pathological changes associated with *Oesophagostomum columbianum* infestation in sheep: haematological observations on control worm-free and experimentally infested sheep. Australian Journal of Agricultural Research, **18**: 523-538.

Dobson, R.J., Donald, A.D., Waller, P.J. and Snowdon, K.L. (1986). An egg hatch assay for resistance to levamisole in trichostrongyloid nematode parasites. Veterinary Parasitology, **19**(1/2): 77-84.

Doll, E.R. and Hull, F.E. (1944). Nematode parasitism of sheep. Journal of American Veterinary Medical Association, **105**: 13-21.

Donald, A.D. (1967). A new technique for the recovery of strongyloid infective larvae from small sample of pasture. Journal of Helminthology, **41**: 1-10.

Donald, A.D. (1968). Ecology of the free-living stages of nematode parasites of sheep. Australian Veterinary Journal, **44**: 139-144.

Downey, N.E. (1969). Grazing management in relation to trichostrongylid infestation in lambs. 2. Level of infestation associated with increased stocking rate and its effects on the host. Irish Journal of Agricultural Research, **8**: 375-395.

Downey, N.E. and Conway, A. (1968). Grazing management in relation to trichostrongylid infestation of lambs. I. Influence of stocking rate on the level of infestation. Irish Journal of Agricultural Research, **7**: 343-362.

Doxey, D.L. (1983). Veterinary Clinical Parasitology, 2nd edition. Bailliere Tindall, London.

Dunn, A.M. (1978). Veterinary Helminthology, 2nd edition. William Heinemann Medical Books Ltd., London, 323 pp.

Dunsmore, J.D. (1965). *Ostertagia* spp. in lambs and pregnant ewes. Journal of Helminthology, **39**: 159-184.

Durie, P.H. (1959). A new technique for the recovery of infective strongyle larvae from soil and pasture. Journal of Helminthology, **41**: 1-10.

Edgar, G. (1933). Some observations on trichostrongylosis of young sheep. Australian Veterinary Journal, **9**: 149-154.

Edwards, E.E. and Wilson, A.S.B. (1958). Observations on nematode infections of goats and sheep in West Africa. Journal of Helminthology, **32**(4): 195-210.

Edwards, J.R., Wroth, R., Chaneet, G.C.De, Besier, R.B., Karlsson, J., Morcombe, P.W., Dalton-Morgan, G. and Roberts, D. (1986). Survey of anthelmintic resistance in Western Australian sheep flocks. 1. Prevalence. 2. Relationship with sheep management and parasite control practices. Australian Veterinary Journal, **63**(5): 135-144.

Edwards, K., Jepson, R.D. and Wood, K.F. (1960). Value of plasma pepsinogen estimation. British Medical Journal, **1**: 30-32.

Efremov, G. and Braend, M. (1965). Haemoglobin transferrins and albumins of sheep and goats. Proceedings of the 9th European Conference on Animal Blood Group and Biochemical Polymorphism, 313-320.

Efremov, G. and Braend, M. (1966). Haemoglobin N of sheep. Age, breed and seasonal distribution. Animal Production, **8**(2): 161-169.

Egerton, J.R. (1969). The ovicidal and larvicidal effect of thiabendazole on various helminth species. Texas Report on Biology and Medicine, 27 (Suppl. 2): 561-580.

Endrejat, E. (1956). Elektrophoretische Untersuchungen am Blutserum stark Wurmbe fallener Schaflammer. Probleme d. Parasitol. (Borchert, ed.). Akademie-Verlag, Berlin, Germany, 127-132.

Enyenihi, U.K. (1969). Pathogenicity of Neoascaris vitulorum infection in calves. Bulletin of Epizootic Diseases of Africa, **17**: 171-178.

Enyenihi, U.K. (1974). The phenotype and gene frequencies of polymorphic haemoglobin of Nigerian goat breeds. Research in Veterinary Science, **17**: 360-363.

Euzeby, J. (1967). Tapeworm infestation in ruminants and its treatment. Veterinary Medical Review, **213**: 169-185.

Evans, J.V., Blunt, M.H. and Southcott, W.H. (1963). The effects of infection with *Haemonchus contortus* on the sodium and potassium concentrations in the erythrocytes and plasma, in sheep of different haemoglobin types. Australian Journal of Agricultural Research, **14**: 549-558.

Evans, J.V., Harris, H. and Warren, F.L. (1957). Haemoglobin types in British breeds of sheep. Biochemical Journal, **65**: 42.

Evans, J.V., Harrison, H. and Warren, F.L. (1958). Haemoglobin and potassium blood groups in some non-British breeds of sheep and in certain rare British breeds. Nature, **182**: 320-322.

Evans, J.V., King, J.W.B., Cohen, B.L., Harris, H. and Warren, F.L. (1956). Genetics of haemoglobin and blood potassium differences in sheep. Nature, **178**: 849-850.

Evans, J.V. and Turner, H.N. (1965). Haemoglobin type and reproductive performance in Australian Merino sheep. Nature, **207**: 1396-1397.

Evans, J.V. and Whitlock, J.H. (1964). Genetic relationship between maximum haematocrit values and haemoglobin type in sheep. Science, **145**: 1318.

Fabiyi, J.P. (1968). M.Sc. Thesis. Ahmadu Bello University, Zaria.

Fabiyi, J.P. (1970). An investigation into the incidence of goat helminth parasites in the Zaria area of Nigeria. Bulletin of Epizootic Diseases of Africa, **18**: 29-34.

Fabiyi, J.P. (1973). Seasonal fluctuation of nematode infestation in goats in the savanna belt of Nigeria. Bulletin of Epizootic Diseases of Africa, **21**: 277-286.

Fagbemi, B.O., Dipeolu, O.O. (1982). Strongyle infections of small ruminants in Nigeria. Veterinary Parasitology, **11**: 347-353.

F.A.O. (1965). F.A.O. Rome Reports. Agricultural development of Nigeria. 1964-1980. P.B. 503.

F.A.O. (1985). FAO Production Yearbook, **39**: 227.

Fernandez, G.M., Mayer, V.R., Gomez, C.G. and Casca, A.A. (1984). [Blood cells and blood proteins of female sheep of a German mutton breed.] Citohemetologia y proteinemia en hembras ovinas. Fleischaf Archives de Zootecnia, **33**(126): 133-141.

Fesus, L., Varkonyi, J. and Agnes, A. (1983). Biochemical polymorphisms in goats with special reference to the Hungarian native breed. Animal Blood Groups and Biochemical Genetics, **14**: 1-6.

Forsyth, B.A. (1953). Epidemiological studies in helminthosis in sheep in southern New South Wales. Australian Veterinary Journal, **29**: 349-356.

Fourie, P.J.J. (1931). The haematology and pathology of haemonchosis in sheep. Union of South Africa Department of Agriculture, Director of Veterinary Services and Animal Industries Report, **17**: 495-572.

Fowler, M. (1981). Overgrazing in Swaziland? A review of the technical efficiency of the Swaziland herd. Overseas Development Institute, Agricultural Administration Unit, London, 16 pp.

Franklin, M.C., Gordon, H.McL. and Macgregor, C.H. (1946). A study of nutrition and biochemical effects in sheep of infestation with *Trichostrongylus colubriformis*. Journal of the Council for Scientific and Industrial Research, Australia, **19**: 46-60.

Furman, D.P. (1944). Effects of environment upon the free-living stages of *Ostertagia circumcincta* (Stadelmann) Trichostrongylidae. 1. Laboratory Experiments. American Journal of Veterinary Research, **5**: 79-86.

Gall, C. and Huhn, J.E. (1981). Constraints on the development of goat **production**: management, nutrition, diseases and health care. Animal Research and Development, **13**: 7-19.

Gatenby, R.M. (1982). Research on small ruminants in Sub-sahara Africa. **In**: Gatenby and Trail (editors). Small ruminant breed productivity in Africa. Proceedings of a seminar at ILCA, Addis Ababa, Ethiopia, October, 1982, pp. 13-20.

Geldorp van, P.J.A. and Schillhorn van Veen, T.W. (1976). Periparturient rise in faecal helminth egg counts of Udah sheep in the Zaria area of Nigeria. Veterinary Parasitology, **1**: 265-269.

Gettinby, G., Hope-Cawdery, M.J. and Grainger, J.N.R. (1974). Forecasting the incidence of Fascioliasis from climatic data. International Journal of Biometry, **18**: 319-323.

Gettinby, G., McKellan, Q.A., Bairden, K., Theodovidis, Y. and Whitelaw, A. (1985). Comparison of two techniques used for recovery of nematode infective larvae from pasture. Research in Veterinary Science, **39**(1): 99-102.

Gibbs, H.C. (1967). Spring rise in sheep. Proceedings of the World Association for Advances in Veterinary Parasitology, Lyon, July 1967.

Gibbs, H.C. (1973). Transmission of parasites with references to the strongyles of domestic sheep and cattle. Canadian Journal of Zoology, **151**: 281-288.

Gibson, T.E. (1955). Studies on *Trichostrongylus axei*. IV. Factors in the causation of pathogenic effects by *T. axei*. Journal of Comparative Pathology, **65**: 317-324.

Gibson, T.E. (1963). Experiments on the epidemiology of Nematodiriosis. Research in Veterinary Science, **4**: 258-268.

Gibson, T.E. (1965). Examination of faeces for helminth eggs and larvae. Veterinary Bulletin, **35**: 403.

Gibson, T.E. (1973). Recent advances in the epidemiology and control of parasitic gastroenteritis in sheep. The Veterinary Record, **92**: 469-473.

Gibson, T.E. and Everett, G. (1968). Experiments on the control of trichostrongylosis in lambs. Journal of Comparative Pathology, **78**: 427-434.

Gibson, T.E. and Everett, G. (1971). Experiments on the control of gastrointestinal nematodes in lambs. Journal of Comparative Pathology, **81**: 493-498.

Gibson, T.E. and Everett, G. (1972). The acquisition of trichostrongylid infection by grazing lambs. Research in Veterinary Science, **13**: 268-271.

Gibson, T.E. and Everett, G. (1973). Observations on the control of nematodiriasis and trichostrongylosis in sheep. Journal of Comparative Pathology, **83**: 125-132.

Gibson, T.E. and Parfitt, J.W. (1973). The development of resistance to *Trichostrongylus colubriformis* by lambs under conditions of continuous infection. Research in Veterinary Science, **15**(2): 220-223.

Goel, K.C. and Nair, P.G. (1976). Biochemical polymorphism in haemoglobin and transferrin of goats. In Proceedings of the 2nd workshop of all-India co-ordinated Research Project on goat breeding held at the National Dairy Research Institute, Karnal, pp. 22-23.

Gordon, H.McL. (1948). The epidemiology of parasite diseases, with special reference to studies with nematode parasites of sheep. Australian Veterinary Journal, **24**: 17-44.

Gordon, H.McL. (1950). Some aspects of parasitic gastroenteritis of sheep. Australian Veterinary Journal, **26**: 14-28, 46-52.

Gordon, H. McL. (1953). The epidemiology of helminthosis in sheep in winter rainfall regions of Australia. 1. Preliminary observations. Australian Veternary Journal, **39**: 337-348.

Gordon, H.McL. (1958a). The effect of worm parasites on the productivity of sheep. Proceedings of the Australian Society for Animal Production, **2**: 59-68.

Gordon, H.McL. (1958b). The epidemiology of helminthosis in sheep in winter rainfall regions of Australia. 2. Western Australia. Australian Veterinary Journal, **34**: 5.

Gordon, H.McL. (1963). Helminth disease of sheep in Australia. Veterinar-Medizinische Nachrichter, **2/3**: 9-29.

Gordon, H.McL. (1964). Studies on resistance to *Trichostrongylus colubriformis*. Influence on a quantitative reduction in the ration. Australian Veterinary Journal, **40**: 55-61.

Gordon, H.McL. (1967). The diagnosis of helminthosis in sheep. Veterinary Medical Review, **2/3**: 140-168.

Gordon, H.McL. (1970). Approach to an epidemiological excursion. Journal of Parasitology, **56**: 119-120.

Gordon, H.McL. (1973). Epidemiology and control of gastrointestinal nematodes of ruminants. Advances in Veterinary Science, **17**: 395-437.

Graham, J.M. and Charleston, W.A.G. (1971). The pathogenicity of *Bunostomum trigonocephalum* for sheep. Veterinary Medical Review, **4**: 452-464.

Hackett, P.L., Gaylor, P.W. and Bustard, L.K. (1957). Blood constituents in Suffolk ewes and lambs. American Journal of Veterinary Research, **18**: 338-341.

Haenlein, G.F.W. and Devendra, C. (1983). Appropriate nutrition for goat production in the tropics. Provisional report No. 14, 79-101.

Hall, C.A., Campbell, N.J. and Richardson, N.J. (1978). Levels of benzimidazole resistance in *Haemonchus contortus* and *Trichostrongylus colubriformis* recorded from egg hatch test procedures. Research in Veterinary Science, **25**: 360-363.

Hall, H.T.B. (1977). Diseases and parasites of livestock in the tropics. Intermediate Tropical Agriculture Series. Longman Group Ltd., 288 pp.

Harrison, H. and Warren, F.L. (1955). Occurrence of electrophoretically distinct haemoglobins in ruminants. Proceedings of the Biochemical Society. Biochemical Journal, **60**: 29.

Hart, J.A. (1964). Observations on the dry season strongyle infections of zebu cattle in Northern Nigeria. British Veterinary Journal, **120**: 87-95.

Heath, G.B.S. (1961). Worms in sheep. Modern Veterinary Practice, **42**: 34-37.

Heath, G.B.S. and Michel, J.F. (1969). A contribution to the epidemiology of parasitic gastroenteritis in lambs. The Veterinary Record, **85**: 305-308.

Heinz, K. (1982). Goat rearing in Africa - its advantages and disadvantages. Animal Research and Development, **15**: 91-109.

Helm van der, H.J., Vliet van, G. and Huisman, T.H.J. (1957). Investigations on two different haemoglobins of the sheep. Archives of Biochemistry and Biophysics, **72**: 331-339.

Henry, R.J., Sobel, C. and Berkman, S. (1957). Interferences with Biuret methods for serum proteins. Use of Benedict's qualitative glucose reagent as a Biuret reagent. Annals of Chemistry, **29**: 1491-1495.

Herlich, H. (1956). A digestion method for post-mortem recovery of nematodes from ruminants. Proceedings of the Helminthological Society of Washington, **23**(2): 102-103.

Herlich, H. (1965). Immunity and cross immunity to *Cooperia oncophora* and *Cooperia pectinata* in calves and lambs. American Journal of Veterinary Research, **26**: 1037-1041.

Herlich, H. (1978). The importance of helminth infections in ruminants. World Animal Review, **26**: 22-26.

Holman, H.H. (1944). Studies on the haematology of sheep. 1. The blood picture of healthy sheep. Journal of Comparative Pathology and Therapeutics, **54**: 26-40.

Horak, I.G. and Clark, R. (1966). The pathological physiology of helminth infestation. II. *Oesophagostomum columbianum*. Onderstepoort Journal of Veterinary Research, **33**: 139-160.

Hotson, I.K. (1967). *Ostertagia*sis in cattle. Australian Veterinary Journal, **43**: 383-387.

Huisman, T.H.J. (1970). **In**: H. Peters (editor), Protides of the biological fluids. Proceedings of the 17th Coll., Bruges (1969). Pergamon Press, pp 242-248.

Huisman, T.H.J., Brandt, G. and Wilson, J.B. (1968). The structure of goat haemoglobins A and B. Journal of Biological Chemistry, **243**: 3675-3686.

Huisman, T.H.J., Vliet van, G. and Sebens, T. (1958a). Sheep haemoglobins. Nature, London, **182**: 171-174.

Huisman, T.H.J., Helm van der, H.J., Visser, H.K,G, and Vliet van, G. (1958b). **In**: Abnormal Haemoglobin, p. 181. Edited by Jonxis, J.H.P. and Delafresnaye, J.F. **Oxford**: Blackwell Scientific Publications Ltd.

Huisman, T.H.J., Wilson, J.B. and Adams, H.R. (1967). The heterogeneity of goat haemoglobin. Evidence for the existence of two non-allelic α and one allelic chain structural genes. Archives of Biochemistry and Biophysics, **127**: 528-530.

Hunter, A.R. and Mackenzie, G. (1982). The pathogenesis of a single challenge dose of *Haemonchus contortus* in lambs under six months of age. Journal of Helminthology, **56**: 135-144.

ILCA (1979). Small ruminant production in the humid tropics. Systems study No. 3. ILCA, Addis Ababa.

Irfan, M. (1967). The electrophoretic pattern of serum proteins in normal animals. Research in Veterinary Science, **8**: 137-142.

Jambre, Le, L.F. (1976). Egg hatch as an *in vitro* assay of thiabendazole resistance in nematodes. Veterinary Parasitology, **2**: 385-391.

Jambre, Le, L.F., Southcott, W.H. and Dash, K.M. (1976). Resistance of selected lines of *Haemonchus contortus* to thiabendazole, morantel tartrate and levamisole. International Journal of Parasitology, **6**: 217-222.

Jansen, J. (1968). Some observations on the "spring rise" in sheep. Tijdschr Diergeneesk, **93**: 422-430.

Jehan, M. and Gupta, V. (1974). The effects of temperature on the survival and development of the free-living stages of twisted wire-worm *Haemonchus contortus* Rudolphi, 1803 of sheep and other ruminants. Zeit Schrift fur Parasitenkunde, **43**(3): 197-208.

Jennings, F.W., Armour, J., Lawson, D.D. and Roberts, R. (1966). Experimental *Ostertagia ostertagi* infections in **calves**: studies with abomasal cannulas. American Journal of Veterinary Research, **27**(120): 1249-1257.

Jilek, A.F. and Bradley, R.E. (1969). Haemoglobin types and resistance to *Haemonchus contortus* in sheep. American Journal of Veterinary Research, **30**(10): 1773-1778.

Joshi, S.C., Rawat, J.S. and Pandey, M.D. (1975). Haemoglobin polymorphism in goats. Current Science, **44**: 673.

Jubb, K.V.F. and Kennedy, P.C. (1970). Pathology of Domestic Animals. 2nd edition. Academic Press, New York and London.

Kates, K.C. (1965). Ecological aspects of helminth transmission in domesticated animals. American Zoologist, **5**: 95-130.

Kates, K.C. and Turner, J.H. (1960). Experimental trichostrongylosis (axei) in lambs with a discussion of recent research on this disease in ruminants. American Journal of Veterinary Research, **21**: 254-261.

Keay, G. and Doxey, D.L. (1983). Serum albumin values from healthy cattle, sheep and horses determined by the immediate bromocresol green reaction and by agarose gel electrophoresis. Research in Veterinary Science, **35**: 58-60.

Kelly, J.D. and Dineen, J.K. (1973). The suppression of rejection of Nippostrongylus brasiliensis in Lewis strain rats treated with ovine **prolactin**: the rate of the immunological defect. Immunology, **24**: 551-558.

Kelly, J.D., Gordon, H.McL. and Whitlock, H.V. (1976). Anthelmintics for **sheep**: Historical perspectives, classification/usage, problem areas and future prospects. New South Wales Veterinary Proceedings, **12**: 18-30.

Kelly, J.D. and Hall, C.A. (1979). Resistance of animal helminths to anthelmintics. Advances in Pharmacology and Chemotherapy, **16**: 89-128.

Kerboeuf, D. (1977). Changes in pepsinogen, proteins and lipids in the serum during experimental haemonchosis in sheep. Annales de Recherches Vtrinaires, **8**(3): 257-266.

Kerboeuf, D. (1980). [Usefulness of pepsinogen level measurements for diagnosing abomasal strongylosis.] Intrt du dosage du pepsinogne sanguin dans le diagnostic des strongyloses des ruminants. In Proceedings of the 2nd International Symposium of Veterinary Laboratory Diagnosticians, 24-26 June, 1980. Lucerne Switzerland, Reiseburo Kuoni, A.G. 181-184.

Kerboeuf, D. and Leimbacher, F. (1977). [The usefulness of serum pepsinogen in ovine parasite epidemiology, preliminary study in Limousin.] Emploi du dosage du pepsinogne srique en epidmiologie parasitaire **ovine**: essai prliminaire dans le Limousin. Recueil de Medecine Veterinaire de L'ecole, **153**(1): 19-25.

Khanolker, V.R., Naik, S.N., Boxi, A.J. and Bhatia, H.M. (1963). Studies on haemoglobin variants and glucose-6-phosphate. Experimentia, **19**: 473.

King, J.W.B., Evans, J.V., Harris, H. and Warren, F.L. (1958). The performance of sheep with differing haemoglobin and potassium blood types. Journal of Agricultural Science, Cambridge, **51**: 342-346.

Kingsbury, P.A. (1965). Relationship between egg counts and worm burdens of young sheep. The Veterinary Record, **77**: 900-901.

Kitchen, H., Eaton, J.W. and Taylor, W.J. (1968). Rapid production of a haemoglobin by induced haemolysis in sheep. Haemoglobin C. American Journal of Veterinary Research, **29**(2): 281-289.

Kohn, J. (1970). Electrophoresis on cellulose acetate. Shandon Instrument Applications No. 11.

Kuil, H. (1970). Gastrointestinal nematodes of sheep in the Zaria area of Northern Nigeria. Report on an investigation subsidised by the Netherlands Foundation for the Advancement of Tropical Research, 1968-70, Zaria, Nigeria.

Kuttler, K.L. and Marble, D.W. (1960). Serum protein changes in lambs with naturally acquired nematode infections. American Journal of Veterinary Research, **21**: 445-448.

Lancaster, M.B. (1970). The recovery of infective nematode larvae from herbage samples. Journal of Helminthology, **44**(2): 219-230.

Lee, R.P., Armour, J. and Ross, J.G. (1960). The seasonal variation of strongyle infestations in Nigerian zebu cattle. British Veterinary Journal, **116**: 34-36.

Leland, S.E. Jr., Drudge, J.H. and Wyant, Z.N. (1959). Studies on *Trichostrongylus axei* (Cobbold, 1879). III. Blood and plasma volume, total serum protein and electrophoretic serum fractionization in infected and uninfected calves. Experimental Parasitology, **8**: 383-412.

Levine, N.D. (1959). Does pasture rotation control sheep parasites? Illinois Research **1**: 12-13.

Levine, N.D. (1963). Weather, climate and the bionomics of ruminant nematode larvae. Advances in Veterinary Science, **8**: 215-261.

Levine, N.D. and Clark, D.T. (1961). The relation of weekly pasture rotation to acquisition of gastrointestinal nematodes by sheep. Illinois Veterinarian, **4**: 89-97.

Levine, N.D., Clark, D.T., Bradley, R.E. and Kantor, S. (1975). Relationship of pasture rotation to acquisition of gastrointestinal nematodes of sheep. American Journal of Veterinary Research, **36**(10): 1459-1464.

Levine, N.D., Todd, K.S. Jr. and Boatman, P. (1974). Development and survival of *Haemonchus contortus* on pasture. American Journal of Veterinary Research, **35**: 1413-1422.

Leyva, V., Henderson, A.E. and Sykes, A.R. (1982). Effect of daily infection with *Ostertagia circumcincta* larvae on food intake, milk production and wool growth in sheep. Journal of Agricultural Science, U.K., **9**(2): 249-259.

Litt, M. (1961). Studies on experimental eosinophilia,. III. The induction of peritoneal eosinophilia by the passive transfer of serum antibody. Journal of Immunology, **87**: 522-529.

Litt, M. (1963). Studies on experimental eosinophilia. V. Eosinophils in lymph nodes of guinea pigs following primary antigenic stimulation. American Journal of Pathology, **42**: 529-547.

Loggins, P.E., Swanson, L.E. and Koger, M. (1965). Parasite levels in sheep as affected by heredity. Journal of Animal Science, **24**: 286-287.

Lucker, J.T. and Neumayer, E.M. (1946). Experiments on the pathogenicity of hookworms (*Bunostomum trigonocephalum*) infections in lambs fed an adequate diet. American Journal of Veterinary Research, 7: 101-122.

Mack, S. (1982). Disease as a constraint to productivity. **In**: Gatenby and Trail (Editors). Small ruminant breed productivity in Africa. Proceedings of a seminar held at IICA, Addis Ababa, Ethiopia in October 1982, pp. 81-83.

Mack, S.D., Sumberg, J.E. and Okali, C. (1985). Small ruminant production under **pressure**: the example of goats in south-east Nigeria. **In**: Sheep and goats in the humid West Africa. Sumberg and Cassaday (Editors). Proceedings on the workshop on small ruminant production systems in the humid zone of West Africa held in Ibadan, Nigeria, 23-26 January, 1984, pp. 47-52.

Matthewman, R.W. (1977). A survey of small livestock production at the village level in the derived savanna and lowland forest zones of south-west Nigeria. University of Reading Study No. 24.

Matthewman, R.W. (1980). Small ruminant production in the humid tropical zone of southern Nigeria. Tropical Animal Health and Production, **12**: 234-242.

McCulloch, B. and Kasimbala, S. (1970). The pathogenic importance of gastrointestinal nematodes for sheep and goats in relation to the need for the economic development of the livestock industry of Sukumaland, Tanzania. East African Agricultural and Forestry Journal, **36**: 20-34.

McIntosh, R.A. (1944). Stomach worm disease in sheep. Canadian Journal of Comparative Medicine, **8**(8): 213.

McKenna, P.B. (1981). The diagnostic value and interpretation of faecal egg counts in sheep. New Zealand Veterinary Journal, **29**(8): 129-132.

McKinney, G.T. (1974). Management of lucerne for sheep grazing on the southern Tablelands of New South Wales. Australian Journal of Experimental Agriculture and Animal Husbandry, **14**: 726-734.

McMeekan, C.P. (1954). Good rearing of dairy stock. Proceedings of the Ruakura Farmers Conference Week, pp. 186-233.

M'Fadyean, J. (1897). Parasitic gastroenteritis in sheep and lambs. Journal of Pathology, **10**: 48-63.

Michel, J.F. (1964). Helminthiasis and grazing management. Agriculture, London, **71**(2): 80-83.

Michel, J.F. (1966). The epidemiology and control of parasitic gastroenteritis in calves. Proceedings of the 4th International Meeting of World Association of Buiatrics, 272-288.

Michel, J.F. (1968). Faecal egg counts in infections of gastrointestinal nematodes in cows. The Veterinary Record, **82**: 132-133.

Michel, J.F. (1969). The epidemiology and control of some nematode infections of grazing animals. **In**: Advances in Parasitology, **7**: 211-272. (B. Dawes, editor).

Michel, J.F. (1971). Some reflections on the study of epidemiological problems in veterinary parasitology. **In**: Centraal Diergeneeskunding Institut, Facts and **Reflections**: A symposium. The Institute, Lelystad, pp. 19-29.

Michel, J.F. (1976a). The epidemiology and control of some nematode infections in grazing animals. Parasitology, **14**: 355-397.

Michel, J.F. (1976b). The hazard of nematode infections as a factor in the management of cattle. ADAS (Agricultural Development Advisory Service), **20**: 162-177.

Michel, J.F. and Parfitt, J.W. (1956). An experimental study of the epidemiology of parasitic bronchitis in calves. The Veterinary Record, **68**: 706-710.

Michell, A.R. (1975). Relationship between **sodium** preference and haemoglobin type in sheep. British Veterinary Journal, **131**: 222-230.

Milovan, E. and Granciu, I. (1978). Genetic variants of haemoglobins and transferrins electrophoretically determined in Carpathian goats (Capra hircus L.). Revue Roumaine de Biologie, Serie de Zoologie, **23**(1): 101-103.

Ministry of Agriculture, Fisheries and Food (1979). Technical Bulletin No. 18. Manual of Veterinary Parasitological Laboratory Techniques. **London**: Her Majesty's Stationery Office, 129 pp.

Misra, S.C. and Ruprah, N.S. (1972). *Haemonchus contortus* infection in experimental lambs. Indian Veterinary Journal, **49**: 554-560.

Mizelle, J.D. and Berberian, J.A. (1953). Development rate of the sheep stomach worm *Haemonchus contortus*. Proceedings of the Indian Academy of Science (1952), **62**: 320.

Morgan, D.O. and Sloan, J.E.N. (1947). Research on helminths in hill sheep with special reference to seasonal variations in worm egg output. Scottish Journal of Agriculture, **27**: 28-33.

Morgan, D.O., Parnell, I.W. and Rayski, C. (1950). Further observations on the seasonal variation in worm egg output in Scottish hill sheep. Journal of Helminthology, **24**(3): 101-122.

Morgan, D.O., Parnell, I.W. and Rayski, C. (1951). The seasonal variations in the worm burden of Scottish hill sheep. Journal of Helminthology, **25**: 177-212.

Morley, F.H.W. (1978). Animal production studies on grassland. **In**: Measurements of grassland productivity. (L. t'Mannetje, editor). CAB, London, pp. 103-162.

Morley, F.H.W. and Donald, A.D. (1980). Farm management and systems of helminth control. Veterinary Parasitology, **6**: 105-134.

Mudaliar, S.V. (1945). Fatal enteritis in goats due to immature amphistomes, probably Cotylophoron cotylophorum. Indian Journal of Veterinary Science, **15**(1): 54-56.

Mulligan, W., Dalton, R.G. and Anderson, N. (1963). *Ostertagia*sis in cattle. The Veterinary Record, **75**: 1014.

Mylrea, P.J. and Hotson, I.K. (1969). Serum pepsinogen activity and the diagnosis of bovine *ostertagia*sis. British Veterinary Journal, **125**: 379-388.

Narain, B. and Chaudhry, H.S. (1971). Effect of temperature on the free-living stages of *Haemonchus contortus*. Indian Biologist, **3**: 54-56.

Obi, T.U. (1980). Symptomalogy. **In**: Peste des petits ruminants (PPR) in sheep and goats. (Hill, D.H., editor). Proceedings of the international workshop held at IITA, Ibadan, Nigeria, 24-26 September, 1980.

Obst, J.M. and Evans, J.V. (1970). Genotype-environment interactions in lamb mortality with particular reference to birth coat and haemoglobin type. Proceedings of the Australian Society of Animal Production, **8**: 149-153.

Oduye, O.O. (1976). Haematological values of Nigerian goats and sheep. Tropical Animal Health and Production, **8**: 131-136.

Ogunsusi, R.A. (1978). Changes in blood values of sheep suffering from acute ad chronic helminthiasis. Research in Veterinary Science, **25**: 298-301.

Ogunsusi, R.A. (1979). Pasture infectivity with trichostrongylid larvae in the Northern Guinea savanna of Nigeria. Research in Veterinary Science, **26**: 320-323.

Okon, E.D. and Akinpelu, A.I. (1982). Development and survival of nematode larvae on pasture in Calabar, Nigeria. Tropical Animal Health and Production, **14**: 23-25.

Okon, E.D. and Enyenihi, U.K. (1975). Infectivity of *Haemonchus contortus* and *Trichostrongylus colubriformis* larvae on pasture at Ibadan. Bulletin de l'Office International des Epizootics, Paris, **83**: 1139-1144.

Okon, E.D. and Enyenihi, U.K. (1977). Development and survival of *Haemonchus contortus* larvae on pastures in Ibadan. Tropical Animal Health and Production, **9**: 7-10.

Ollerenshaw, C.B. and Rowlands, W.T. (1959). A method of forecasting the incidence of fascioliasis in Anglesey. The Veterinary Record, **71**: 591-598.

Ollerenshaw, C.B. and Smith, L.P. (1966). An empirical approach to forecasting the incidence of nematodiriasis over England and Wales. The Veterinary Record, **79**: 536-540.

Ollerenshaw, C.B. and Smith, L.P. (1969). Meteorological factors and forecasts of helminth disease. Advances in Parasitology, **7**: 283-323.

Olusanya, S.K. (1975). Electrolyte concentration and haemoglobin types in the blood of Nigerian Dwarf sheep. Journal of Nigerian Veterinary Medical Association, **4**(2): 59-63.

Opasina, B.A. and Dipeolu, O.O. (1983). Fatal infection of West African Dwarf sheep with Mammomonogamus nasicola (Syngamus nasicola). Zentralblatt fur Veterinarmedizin B., **30**(4): 313-315.

Oppong, E.N.W. and Yebuah, N.M.N. (1981). Some production traits of the West African Dwarf goat. Tropical Animal Health and Production, **13**: 208-212.

Ortlepp, R.J. (1939). Observations on the life history of *Bunostomum trigonocephalum*, a hookworm of sheep and goats. Onderstepoort Journal of Veterinary Science, **12**(2): 305-318.

Oshio, Y. (1952). Studies on the anaemia by *Haemonchus contortus*. I. On the anaemia producing substance. Bulletin of the National Institute of Agricultural Series. Chiba Series 6. Animal Husbandry No. 3, pp. 171-178.

Osterhoff, D.R. and Ward-Cox, I.S. (1972). Serum polymorphism in three South African goat breeds. Proceedings of the 12th European Conference on Animal Blood Groups and Biochemical Polymorphism, 579-582.

Parfitt, J.W. (1955). Two techniques for the detection and enumeration of the larvae of *Dictyocaulus* viviparus in faeces and in herbage. Laboratory Practice, **4**: 15-16.

PCARR (1977). Philippine Council for Agriculture and Resources Research. The Philippines recommendations for goat farming.

Peters, K.J. and Horst, P. (1981). Development potential of goat breeding in the tropics and subtropics. Animal Research and Development, **14**: 54-71.

Peters, K.J., Deichert, G., Drewes, E., Fichtner, G. and Moll, S. (1981). Goat production in low income economic units of selected areas in West Malaysia. Animal Research and Development, **13**: 88-113.

Pomroy, W.E., Lambert, M.G. and Betteridge, K. (1986). Comparison of faecal strongylate egg counts of goats and sheep on the same pasture. New Zealand Veterinary Journal, **34**(3): 36-37.

Porter, D.A. (1953). Cross transmission of parasitic worms between sheep and cattle. American Journal of Veterinary Research, **14**: 550-554.

Pradhan, S.L. and Johnstone, I.L. (1972). *Haemonchus contortus*: Haematological changes in lambs during prolonged exposure to daily and weekly doses of infective larvae. Parasitology, **64**: 153-160.

Preston, J.M. and Allonby, E.W. (1978). The influence of breed on the susceptibility of sheep and goats to a single experimental infection with *Haemonchus contortus*. The Veterinary Record, **103**: 509-512.

Preston, J.M. and Allonby, E.W. (1979a). The influence of haemoglobin phenotype on the susceptibility of sheep to *Haemonchus contortus* infection in Kenya. Research in Veterinary Science, **26**: 140-144.

Preston, J.M. and Allonby, E.W. (1979b). The influence of breed on the susceptibility of sheep to *Haemonchus contortus* infection in Kenya. Research in Veterinary Science, **26**: 134-139.

Prichard, R.K., Hall, C.A., Kelly, J.D., Martin I.C.A. and Donald, A.D. (1980). The problem of anthelmintic resistance in nematodes. Australian Veterinary Journal, **56**(5): 239-250.

Pullan, N.B. and Sewell, M.M.H. (1980). A modified procedure for the extraction of infective larvae from bovine faeces. Veterinary Research Communication, **4**: 307-310.

Pullar, E.M. (1953). The epidemiology of helminthosis in sheep in winter rainfall regions of Australia. Australian Veterinary Journal, **29**: 357-362.

Radhakrishan, C.V., Bradley, R.E. and Loggins, P.E. (1972). Host responses of worm-free Florida Native and Rambouillet lambs experimentally infected with *Haemonchus contortus*. American Journal of Veterinary Research, **33**(4): 817-823.

Raisinghari, P.B., Ghosal, A.K. and Singh, B.B. (1971). Studies on lambs experimentally infected with *Haemonchus contortus*. Indian Veterinary Journal, **48**: 112-115.

Ramson, B.H. (1906). The life cycle of the twisted wire worm (*Haemonchus contortus*) of sheep, cattle and other ruminants. Circular 93, U.S.D.A. Bureau Animal Industry, 1-7.

Reinecke, R. (1960). A field study of some nematode parasites of bovines in a semi-arid area, with special reference to their biology and possible methods of prophylaxis. Onderstepoort Journal of Veterinary Research, **28**: 365-464.

Ritchie, J.S.D., Anderson, N., Armour, J., Jarret, W.F.H., Jennings, F.W. and Urquhart, G.M. (1966). Experimental *Ostertagia ostertagi* infections in calves. American Journal of Veterinary Research, **27**: 659-667.

Roberts, F.H.S. (1942). The host specificity of sheep and cattle helminths, with particular reference to the use of cattle in cleansing sheep pastures. Australian Veterinary Journal, **18**: 19-27.

Roberts, F.H.S. (1957). Reactions of calves to infestation with the stomach worm, *Haemonchus placei* (Place, 1893) Ramson, 1911. Australian Journal of Agricultural Research, **8**: 740-767.

Roberts, F.H.S., O'Sullivan, P.J. and Rick, R.F. (1952). The epidemiology of parasitic gastroenteritis of cattle. Australian Journal of Agricultural Research, **3**: 187-226.

Roberts, J.L. and Swan, R.A. (1981). Quantitative studies of ovine haemonchosis. 1. Relationship between faecal egg counts and total worm counts. Veterinary Parasitology, **8**: 165-171.

Roberts, J.L. and Swan, R.A. (1982). Quantitative studies of ovine haemonchosis. 2. Relationship between total worms counts of *Haemonchus contortus*, haemoglobin values and body weight. Veterinary Parasitology, **9**: 201-209.

Rogers, W.P. (1940). The effects of environmental conditions on the accessibility of third stage *Trichostrongylus* larvae to grazing animals. Parasitology, **32**(2): 208-225.

Rose, J.H. (1968). Species of gastrointestinal nematodes of cattle in south-east England. The Veterinary Record, **82**: 615-617.

Ross, J.G. (1963). Experimental infections of calves with the nematode parasite *Ostertagia ostertagi*. The Veterinary Record, **75**: 129-131.

Ross, J.G. (1970). The Stormont "wet day" forecasting system for fascioliasis. British Veterinary Journal, **126**: 401-408.

Ross, J.G. (1975). A study of the application of the Stormont "wet day" fluke forecasting system in Scotland. British Veterinary Journal, **131**: 486-497.

Ross, J.G. and Purcell, D.A. (1969). The effect on infectivity and pathogenicity of cross infection of *Trichostrongylus axei* from sheep to cattle. The Veterinary Record, **84**: 49.

Rossiter, L.W. (1964). The epizootiology of nematode parasites of sheep in the coastal area of the Eastern province. Onderstepoort Journal of Veterinary Research, **31**(2): 143-150.

Round, M.C. (1963). Observations on *Strongyloides papillosus* infection. The treatment of heavy naturally acquired infections of sheep in Kenya. British Veterinary Journal, **119**: 253-262.

Rubin, R. (1967). Some observations on the interpretations of faecal egg counts. American Journal of Veterinary Clinical Pathology, **1**: 145-148.

Saad, A.M., Hussein, M.F., Dargie, J.D. and Taylor, M.G. (1984). The pathogenesis of experimental Schistosoma bovis infections in Sudanese sheep and goats. Journal of Comparative Pathology, **94**: 371-385.

Salih, N.E. and Grainger, J.N.R. (1982). The effect of constant and changing temperatures on the development of eggs and larvae of *Ostertagia circumcincta*. Journal of Thermal Biology, **7**: 35-38.

Salisbury, J.R. and Arundal, J.H. (1970). The relationship between lactation and post-parturient rise in faecal nematode egg counts of ewes. Australian Veterinary Journal, **46**: 267-271.

Santos Matos, M., Souza de R.M., Santos, L., Dos, M.M., Ribiero, O.C., Costa Santos, J.A. and Borges, W.M. (1982). [Haemoglobin, haematocrit and leucocyte counts in goats.] Haemoglobina, volume globular & leucocitos em carpi nos. Arquives da Escola de Medicina Veterinaria da Universidade Federal da Bolivia, **7**(1): 82-90.

Schalm, O.W. (1965). Veterinary haematology, 2nd edition. Lea and Febiger, Philadelphia.

Schillhorn van Veen, T.J. (1973). Small ruminant health problems in Northern Nigeria with emphasis on the helminthiasis. Nigerian Veterinary Journal, **2**(1): 26-31.

Schillhorn van Veen, T.W. (1974). Drought, malnutrition and parasitism. Nigerian Journal of Animal **Production,1**: 231-236.

Schillhorn van Veen, T.W. (1978). *Haemonchus* in sheep during the dry season in the Nigerian savanna. The Veterinary Record, **102**: 364-365.

Schillhorn van Veen, T.W. (1982). Role of parasitism in goat management. Proceedings of the 3rd International Conference on Goat Production and Diseases, Tusson, **2**: 85-89.

Schillhorn van Veen, T.W. and Brinckman, W.L. (1975). An evaluation of anthelmintic drenching schemes for lambs on wet season grazing. Samaru Agricultural Newsletter, **17**: 72-79.

Schillhorn van Veen, T.W. and Fularanmi, D.O.B. (1978). The haemoglobin types of Northern Nigerian sheep. Research in Veterinary Science, **25**: 397-398.

Scott, H.L., Silverman, P.H., Mansfield, M.E. and Levine, H.S. (1971). *Haemonchus contortus* infection in sheep. Active and passive immunity in sheep given oral iron supplementation. American Journal of Veterinary Research, **32**: 249-262.

Scrivner, L.H. (1964). Breed resistance in *Ostertagia*sis in sheep. Journal of the American Veterinary Medical Association, **144**(8): 883-887.

Shastry, K.N.V. and Ahluwalia, S.S. (1972). Changes in serum protein of goats experimentally infected with *Haemonchus contortus*. The Indian Veterinary Journal, **49**(5): 470-472.

Sheriff, D. and Habel, J.D. (1976). Sheep haematology in diagnosis. Veterinary Review No. 16, The University of Sydney, The Post-graduate Foundation in Veterinary Science.

Shorb, D.A. (1943). Survival on grass plots of eggs and pre-infective larvae of the common sheep stomach worm, *Haemonchus contortus*. Journal of Parasitology, **29**: 284-289.

Shorb, D.A. (1944). Factors influencing embryonation and survival of eggs of the stomach worm *Haemonchus contortus*. Journal of Agricultural Research, **69**: 279-287.

Shumard, R.F., Bolin, D.W. and Eveleth, D.F. (1957). Physiological and nutritional changes in lambs infected with nematodes, *Haemonchus contortus*, *Trichostrongylus colubriformis* and *Nematodirus* spathiger. American Journal of Veterinary Research, **18**: 330-337.

Siegmund, O.H. (Editor) (1973). The Merck Veterinary Manual. A handbook of diagnosis and therapy for the Veterinarian. Merck and Co. Inc., Rahway, N.J., U.S.A.

Silverman, P.H. and Campbell, J.A. (1959). Studies on parasitic worms of sheep in Scotland. Embryonic and larval development of *Haemonchus contortus* at constant conditions. Parasitology, **49**: 23-28.

Silverman , P.H. and Patterson, J.E. (1960). Histotrophic (parasitic) stages of *Haemonchus contortus*. Nature, **185**: 54-55.

Silverman, P.H., Mansfield, M.E. and Scott, H.C. (1970). *Haemonchus contortus* infection in **sheep**: effects of various levels of primary infections on non-treated lambs. American Journal of Veterinary Research, **31**: 841-857.

Singh, H., Taudon, S.N., Joshi, J.D. and Khanna, N.D. (1977). Studies on some blood protein polymorphisms in indigenous goats. Indian Veterinary Journal, **54**: 884-887.

Skerman, K.D. and Hilliard, J.J. (1966). A handbook for studies of helminth parasites of ruminants. Near East Animal Health Institute, Handbook No. 2, F.A.O., Rome.

Smith, H.J. and Archibald, R.McG. (1969). Development of cross immunity in lambs by exposure to bovine gastrointestinal parasites. Canadian Veterinary Journal, **10**: 286-290.

Somvanshi, R., Biswas, J.C., Sharma, B. and Koul, G.L. (1987). Haematological studies on Indian pashmina goats. Research in Veterinary Science, **42**(1): 124-126.

Sood, S.M. (1960). On a hitherto unrecorded observation regarding the sheep nodular worm infection. Indian Veterinary Journal, **37**(6): 303-305.

Soulsby, E.J.L. (1962). Animal Health and Production, 1st edition. Butterworths, London.

Soulsby, E.J.L. (1965). The textbook of Veterinary Clinical Parasitology. Vol. 1. Helminths. 1st edition, Blackwell Scientific Publications, Oxford.

Soulsby, E.J.L. (1968). Helminths, Arthropods and Protozoa of domesticated animals. The English Language Book Society. Baillière Tindall and Cassell Ltd., London.

Soulsby, E.J.L. (1982). Helminths, Arthropods and Protozoa of domesticated animals. 7th edition. Baillière Tindall and Cassell Ltd., London.

Southcott, W.H. (1971). Management practices and helminthosis in lambs. Australian Veterinary Journal, **47**: 170-174.

Southcott, W.H. and Barger, I.A. (1975). Control of nematode parasites by grazing management. II. Decontamination of sheep and cattle pastures by varying periods of grazing with the alternate host. International Journal of Parasitology, **5**: 45-48.

Southcott, W.H., Major, G.W. and Barger, I.A. (1976). Seasonal pasture contamination and availability of nematodes for grazing sheep. Australian Journal of Agricultural Research, **27**: 277-286.

Spedding, C.R.W. (1954). Effect of a sub-clinical worm burden on the digestive efficiency of sheep. Journal of Comparative Pathology, **64**: 5-14.

Spedding, C.R.W. (1956a). The control of worm infestation in sheep by grazing management. Journal of Helminthology, **29**: 179-186.

Spedding, C.R.W. (1956b). Worm infestation in sheep. Outlook on Agriculture, **1**: 101-110.

Spedding, C.R.W. (1962). Modern trends in animal health and husbandry. The agricultural ecology of sheep grazing. British Veterinary Journal, **118**: 461-481.

Spedding, C.R.W., Betts, J.E., Large, R.V., Wilson, I.A.N. and Penning, P.D. (1967). Productivity and intensive sheep stocking over a five-year period. Journal of Agricultural Science, Cambridge, **69**: 47-69.

Spedding, C.R.W., Brown, T.H. and Large, R.V. (1964). The interaction of internal parasites and nutrition in the utilization of grassland of sheep. Journal of Agricultural Science, **63**: 421-426.

Sprent, J.F.A. (1946). Some observations on the bionomics of *Bunostomum phlebotomum*, a hookworm of cattle. Parasitology, **37**: 202-210.

Srivastava, N.D. (1938). Helminthology in relation to veterinary science. Indian Journal of Veterinary Science, **8**(2): 113-118.

Steel, R.G.D. and Torrie, J.H. (1960). Principles and procedures of statistics. McGraw-Hill Book Company Inc., London.

Stewart, D.F. (1953). Studies on the resistance of sheep to infestation with *Haemonchus contortus* and *Trichostrongylus* spp. and on the immunological reaction of sheep exposed to infection. V. The nature of the self-cure phenomenon. Australian Journal of Agricultural Research, **4**: 100-117.

Stewart, D.F. and Gordon, H.McL. (1958). Immune reactions to *Trichostrongylus colubriformis* infestation in sheep. Nature, **181**(4613): 921.

Stewart, J. (1933). The effect of nematode infestations on the metabolism of the host. Part 1. Metabolism experiments. Report of the Director of the Institute of Animal Pathology (Cambridge), **3**: 58-76.

Stewart, M.A., Miller, R.F., Douglas, J.R. (1937). Resistance of sheep of different breeds to infestation by *Ostertagia circumcincta*. Journal of Agricultural Research Washington, **55**(12): 923-930.

Sumberg, J.E. (1985). Small ruminant feed production in a farming system's context. In Sumberg and Cassaday (editors): Sheep and goats in humid West Africa. Proceedings of the workshop on small ruminant production systems in the humid zone of West Africa, held in Ibadan, Nigeria, 23-26 January, 1984, pp. 41-46.

Sumberg, J.E. and Cassaday, K. (1985). Sheep and goats in humid west Africa. In Sumberg and Cassaday (editors): Sheep and goats in humid West Africa. Proceedings of the workshop on small ruminant production systems in the humid zone of West Africa, held in Ibadan, Nigeria, 23-26 January, 1984, pp. 3-5.

Suten, E. and Kedar, L. (1983). [Variations in plasma pepsinogen levels in gastrointestinal parasitoses in sheep.] Variatile pepsinogenului plasmalic in parazitoze gastrointestinale la ovine. In Lucrarile celui de al 8-lea seminar ameliorarea, technologia si patologia rumegatoarelor, Cluj-Napoca, Romania, 11-12 Noiembrie 1983. Sectia de Patologie. Cluj-Napoca, Romania, Institul Agronomic, Dr. Peter Groza, 165-170.

Swan, G.E., Schroder, J., Carmichael, I.H., Louw, J.P., Harvey, R.G. and Penderis, I. (1984). Efficacy of Ivermectin against internal parasites of sheep. Journal of the South African Veterinary Association, **55**(4): 165-169.

Sykes, A.R. (1978). The effect of subclinical parasitism in sheep. The Veterinary Record, **102**: 32-34.

Taylor, E.L. (1934a). The epidemiology of parasitic gastritis in sheep. Observations on the relative importance of the various factors concerned in the development of the disease. Journal of Agricultural Science, **24**: 192-208.

Taylor, E.L. (1934b). The epidemiology of winter outbreaks of parasitic gastritis in sheep, with special reference to outbreaks which occurred during the winter of 1933-34. Journal of Comparative Pathology, **47**: 235-254.

Taylor, E.L. (1934c). Field experiments on the immunity of lambs to parasitic gastritis caused by a mixed infection of trichostrongylid nematodes. Journal of Helminthology, **12**(3): 143-164.

Taylor, E.L. (1935). Seasonal fluctuations in the numbers of eggs of trichostrongylid worms in the faeces of ewes. Journal of Parasitology, **21**: 175-179.

Taylor, E.L. (1939). Technique for the estimation of pasture infestation by strongyloid larvae. Parasitology, **31**: 473-478.

Taylor, E.L. (1961). Acquired immunity and helminth disease. Journal of Helminthology (R.T. Leiper Supplement), pp 175-178.

Taylor, E.L. and Michel, J.F. (1953). The parasitological and pathological significance of arrested development in nematodes. Journal of Helminthology, **27**: 199-205.

Templeton, J.W., Price, D. and Bugart, R. (1972). Frequency of haemoglobin types in five breeds of sheep. Journal of Heredity, **63**(4): 202-204.

Thapar, G.S. and Singh, K.S. (1954). Studies on the life history of *Trichuris ovis* (Abildgaard, 1795) (fam. **Trichuridae**: Nematoda). Proceedings of the Indian Academy of Science, Section B, **40**(3): 69-88.

Thomas, R.J. (1959). Field studies on the seasonal incidence of *Nematodirus* battus and *N. filicollis* in sheep. Parasitology, **49**: 387-410.

Thomas, R.J. (1974). The role of climate in the epidemiology of nematode parasitism in ruminants. **In**: Taylor, A.E.R. and Muller, R. (Editors). Symposium of the British Society for Parasitology, **12**: 13-32.

Thomas, R.J. and Boag, B. (1972). Epidemiological studies on gastrointestinal nematode parasites of sheep. Infection patterns on clean and summer-contaminated pasture. Research in Veterinary Science, **13**: 61-69.

Thomas, R.J. and Waller, P.J. (1975). Significance of serum pepsinogen and abomasal pH levels in a field infection of *Ostertagia circumcincta* in lambs. The Veterinary Record, **97**: 468-471.

Thomas, R.J., Paston, G. and Waller, P.J. (1986). The application of simulation model to control strategies in ovine gastrointestinal parasitism. Veterinary Parasitology, **21**(2): 127-133.

Tripathi, J.C. (1966). Seasonal variations of egg output of gastrointestinal nematodes of goats. 1. Total egg counts. Indian Journal of Veterinary Science, **36**: 203-210.

Tucker, E.M. (1966). The life span and other physiological properties of sheep red cells containing type A, B or C (N) haemoglobin. Research in Veterinary Science, **7**: 368-378.

Tucker, E.M., Clarke, S.W., Osterhoff, D.R. and Groenewald, J. (1983). An investigation of five genetic loci controlling polymorphic variants in the red cells of goats. Animal Blood Groups and Biochemical Genetics, **14**: 269-277.

Turner, J.H. (1955). Preliminary report of experimental strongyloidiasis in lambs. Proceedings of the Helminthological Society of Washington, **22**(2): 132-133.

Turner, J.H. (1959). Experimental strongyloidiasis in sheep and goats. 1. Single infections. American Journal of Veterinary Research, **20**: 102-110.

Turner, J.H. and Wilson, G.I. (1958). Strongyloidiasis in lambs. Veterinary Medicine, **53**: 242-243.

Turner, J.H. and Wilson, G.I. (1962). Serum protein studies on sheep and goats. 1. Studes on Shropshire lambs exposed to different degrees of parasitism. American Journal of Veterinary Research, **23**(95): 718-724.

Turner, J.H., Shalkop, W.T. and Wilson, G.I. (1960). Experimental strongyloidiasis in sheep and goats. IV. Migration of *Strongyloides papillosus* in lambs and accompanying pathologic changes following percutaneous infection. American Journal of Veterinary Research, **21**: 536-546.

Unsworth, K. (1948). Observations on the occurrence of larvae of *Oestrus ovis* in the nasal cavities and frontal sinuses of goats in Nigeria. Annals of Tropical Medicine and Parasitology, **42**: 249-250.

Uppal, P.K. and Rai, P. (1978). Total serum protein and electrophoretic patterns of serum proteins in experimental infection of Mandya lambs with *Haemonchus contortus*. Indian Journal of Parasitology, **2**(2): 147-149.

Upton, M. (1985). Models of improved production systems for small ruminants. **In**: Sumberg and Cassaday (editors): Sheep and goats in humid West Africa. Proceedings of the workshop on small ruminant production systems in the humid zone of West Africa, held in Ibadan, Nigeria, 23-26 January, 1984, pp. 55-67.

Urquhart, G.M., Jarrett, W.F.H. and Mulligan, W. (1962). Helminth immunity. **In**: Advances in Veterinary Science. Academic Press, New York and London, **7**: 87-129.

Veglia, F. (1915). The anatomy and life history of the *Haemonchus contortus*. Report Veterinary Research South Africa, **3/4**: 347-500.

Vercruysse, J. (1985). The seasonal prevalence of inhibited development of *Haemonchus contortus* in sheep in Senegal. Veterinary Parasitology, **17**(2): 159-163.

Vlassoff, A. (1975). The role of climate in the epidemiology of gastrointestinal nematode parasites of sheep and cattle. **In**: Symposium on Meteorology and Food Production, 14-15 October, 1975, New Zealand Meteorological Service, Wellington, pp. 171-176.

Vliet van, G. and Huisman, T.H.J. (1964). Changes in haemoglobin types of sheep as a response to anaemia. Biochemical Journal, **93**: 401-409.

Waller, P.J. and Donald, A.D. (1970). The response to desiccation of eggs of *Trichostrongylus colubriformis* and *Haemonchus contortus* **(Nematoda**: Trichostrongylidae). Parasitology, **61**: 195-204.

Waller, P.J., Dobson, R.J., Donald, A.D. and Thomas, R.J. (1981). Populations of strongyloid nematode infective stages in sheep **pastures**: comparison between direct pasture sampling and tracer lambs as estimators of larval abundance. International Journal of Parasitology, **11**(5): 359-367.

Wang, G.T. (1967). Effect of temperature and culture methods on development of the free-living stages of *Trichostrongylus colubriformis*. American Journal of Veterinary Research, **28**: 1085-1090.

Warwick, B.L., Berry, R.O., Tuck, R.D. and Morgan, C.O. (1949). Selection of sheep and goats for resistance to stomach worm, *Haemonchus contortus*. Journal of Animal Science, **8**: 609-610.

Wertejule, M. (1959). Influence of environmental conditions on the invasive larvae of gastrointestinal nematodes of sheep. Acta Parasitologica Polonica, **7**: 315-342.

Whitlock, J.H. (1948). Some modifications of the McMaster egg counting techniques and apparatus. Journal of the Council for Scientific and Industrial Research, Australia, **21**: 177-180.

Whitlock, J.H. (1955). The evaluation of pathological growth and parasitic disease. Cornell Veterinarian, **45**: 411-421.

Whitlock, J.H. (1956). An improved method for the culture of nematode larvae in sheep faeces. Australian Veterinary Journal, **32**: 141-143.

Whitlock, J.H. (1958). The inheritance of resistance to trichostrongylidosis in sheep. 1. Demonstration of the validity of the phenomenon. Cornell Veterinarian, **48**: 127-133.

Whitlock, J.H. (1961). Parasitology, biometry and ecology. British Veterinary Journal, **117**: 337-348.

Whitlock, J.H. (1963). A cybernetic approach to natural epidemic of strongylatosis in sheep. Cornell Veterinarian, **53**: 505-534.

Whitlock, J.H., Crofton, H.D. and Georgi, J.R. (1972). Characteristics of parasite populations in endemic trichostrongylidosis. Parasitology, **64**: 413-427.

Whitlock, J.H., Georgi, J.R., Robson, D.S. and Federer, W.T. (1966). **Haemonchosis**: an orderly disease. Cornell Veterinarian, **56**: 544-553.

Whitten, L.K. and Macfarlane, I.M. (1953). The effect of monthly anthelmintic treatment on the growth of young sheep rotationally grazed on hill pastures. New Zealand Veterinary Journal, **1**: 150-153.

Williamson, G. and Payne W.J.A. (1978). The introduction to animal husbandry in the tropics. The English Language Book Society and Longmans, London, pp. 43.

Wilson, A.L., Morgan, D.O., Parnell, I.W. and Rayski, C. (1953). Helminthological investigations on an Argyllshire hill farm. British Veterinary Journal, **109**: 179-190.

Wilson, R.T. (1976). Studies on the livestock of Southern Darfur. IV. Production traits in goats. Tropical Animal Health and Production, **8**: 221-232.

Wilson, R.T. (1980). Population and production parameters of sheep under traditional management in semi-arid areas of Africa. Tropical Animal Health and Production, **12**: 243-250.

Wilson, R.T. (1982). Husbandry, nutrition and production of goats and sheep in tropical Africa. **In**: Gatenby and Trail (editors). Small ruminant breed productivity in Africa pp. 61-75. **ILCA, Addis Ababa**

Wilson, R.T. (1983). Husbandry, nutrition and productivity of goats and sheep in tropical Africa. Joint IFS/ILCA workshop on small ruminant research in the tropics, Addis Ababa, pp. 19-34.

Wrightstone, R.N., Wilson, J.B., Miller, A. and Huisman, T.H.J. (1970). The structure of goat haemoglobin. IV. A third β chain variance (βE) with three apparent amino acid substitutions. Archives of Biochemistry and Biophysics, **138**: 451-456.

Yazwinski, T.A., Greenway, T., Presson, B.L., Pote, L.M., Featherstone, H. and Williams, M. (1983). Antiparasitic efficacy of Ivermectin in naturally parasitized sheep. American Journal of Veterinary Research, **44**(11): 2186-2187.

Young, R.R., Anderson, N., Overend, D., Tweedie, R.L., Malafant, K.W.J. and Preston, G.A.N. (1980). The effect of temperature on times of hatching of eggs of the nematode *Ostertagia circumcincta*. Parasitology, **81**: 477–491.

Zajicek, D. (1973). [Haematological changes associated with *Haemonchus contortus* and *Trichostrongylus colubriformis* infection in lambs and the effect of treatment with Nilvern (tetramisole).] Hematologicke hodnoty psi experimentani invazi *H. contortus* and *T. colubriformis* n jennat a zmeny po Leche Nilverm (ICI). Veteroinaria Medicina, **18**(1): 41–52.

Zimmerman, W.J. (1965). The role of collected management systems in the control of sheep pastures. Journal of American Veterinary Medical Association, **147**(5): 499–505.

APPENDIX 1

BACKGROUND STUDIES ON TRADITIONALLY MANAGED SHEEP AND GOATS

IN THE NORTH WEST PROVINCE OF CAMEROON.

I. Questionnaire for local farmers who do not keep sheep or goats

1. Code number:
   Division:
   Subdivision:
   Village:
   Name of respondent:

2. Level of education:

2.1 Primary school education

2.2 First cycle secondary school education

2.3 Second cycle secondary school education

2.4 Teacher's grade I, II or III certificate

2.5 University education

2.6 Illiterate

3. Family situation:

3.1 Married

3.2 Unmarried

3.3 Head of family

3.4 Number of wives

3.5 Number of sons

3.6 Number of daughters

3.7 Number of other dependents

4. Occupation(s):

4.1 Pure livestock farming

4.2 Crop farming and livestock rearing

4.3 Off-farm work of varying amounts of time

If you have off-farm work, give percentage of time involved

4.4 Greater than 50%

4.5 50%

4.6 Less than 50%

5. Which animals do you keep?

		Total numbers	Numbers of adults
5.1	Pigs		
5.2	Rabbits		
5.3	Guinea pigs		
5.4	Poultry		
5.5	Beef cattle		
5.6	Dairy cattle		
5.7	Horses		
5.8	Other (specify)		
5.9	None		

6&7 Reasons for not keeping sheep or goats 6. Sheep 7. Goats

1. Do not give sufficient income
2. Grazing land not available.
3. Marketing difficulties
4. Destruction caused to environment
5. High mortality in lambs/kids
6. Other (specify)

Additional comments on these reasons:-

APPENDIX 2A

BACKGROUND STUDIES ON TRADITIONALLY MANAGED SHEEP AND GOATS

IN THE NORTH WEST PROVINCE OF CAMEROON.

IIa. Questionnaire for farmers who keep sheep and goats

1. Code number:

Division:

Subdivision:

Village:

Name of respondent:

2. Level of education:

2.1 Primary school education

2.2 First cycle secondary school education

2.3 Second cycle secondary school education

2.4 Teacher's grade I, II or III certificate

2.5 University education

2.6 Illiterate

3. Family situation:

3.1 Married

3.2 Unmarried

3.3 Head of family

3.4 Number of wives

3.5 Number of sons

3.6 Number of daughters

3.7 Number of other dependents

4. Occupation(s):

4.1 Pure livestock farming

4.2 Crop farming and livestock rearing

4.3 Off-farm work of varying amounts of time

If you have off-farm work, give percentage of time involved

4.4 Greater than 50%

4.5 50%

4.6 Less than 50%

INTRODUCTION

5. Have you had any formal training in keeping sheep and/or goats?

5.1 Yes/No

5.2 If Yes, state duration of your training (number of months)

6. How many years have you been rearing sheep and/or goats?

7–11. How many animals are in your flock?

	Females				Males			
	7 lambed/ kidded		8 not lambed/ kidded		9 castrates		10 entire	
	sheep	goats	sheep	goats	sheep	goats	sheep	goats
Under 1 year								
1–2 years old								
2–3 years old								
3–4 years old								
4 years old								
Unknown (about 1–3 years old)								
Unknown (over 3 years old)								
TOTAL								

11. GRAND TOTAL

12. Breakdown of present flock situation by breed (goats)

12.1 Cameroon Dwarf goat

12.2 Rousse (Red Sokoto)

12.3 Saanen

12.4 Nubian

12.5 Toggenburg

12.6 Crosses (local x exotic)

12.7 Others

13. Breakdown of present flock situation by breed (sheep)

13.1 Dwarf Forest sheep

13.2 Fulani Ouda

13.3 Fulani Bornu

13.4 Dorset

13.5 Suffolk

13.6 Crosses (local x exotic)

13.7 Others

14. Which other animals do you keep.

		Total Numbers	Numbers of adults
14.1	Pigs		
14.2	Rabbits		
14.3	Guinea pigs		
14.4	Poultry		
14.5	Beef cattle		
14.6	Dairy cattle		
14.7	Horses		
14.8	Other (specify)		

15. What are your reasons for keeping sheep and/or goats?

15.1 Form of investment

15.2 Lower risk of investment

15.3 Smaller risk of loss by individual death

15.4 Faster turnover of capital

15.5 Low labour requirement

15.6 Hardy and resistant to disease

15.7 Little housing space

15.8 Easy to manage

15.9 Supply meat and/or milk in convenient quantities

15.10 Source of revenue for family needs and social obligations

15.11 Other reasons (specify)

16. If you keep only one type of small ruminants, was the other type previously kept?

16.1 Yes/No

If Yes, why did you give that type up?

16.2 Difficult to manage (specify how)

16.3 Meat quality not to your taste

16.4 Less hardy and more susceptible to disease

16.5 Little turnover of capital

16.6 Lower reproduction efficiency

16.7 Other (specify)

If No, why is one type kept rather than the other?

16.8 More hardy and disease resistant

16.9 Better meat quality (specify)

16.10 Flock habit makes management easier

16.11 Browsing advantage

16.12 Faster turnover of capital

16.13 Other reasons

17. If you have bought any goats or sheep for your flock within the past 12 months, what criteria did you use in selecting them?

17.1 Body conformation

17.2 Teeth and/or horn examination to estimate age

17.3 Udder and testes must be healthy looking and well formed

17.4 Reproductive performance

17.5 Absence of any physical defects

17.6 Coat colour

17.7 Should be a twin

17.8 Good motherly ability

MANAGEMENT

18-21. Systems of management at different seasons and for different age groups.

18/19. Cropping season (March to August)

18. Adults

18.1 Tethering

18.2 Herding

18.3 Extensive production

18.4 Semi-extensive

18.5 Intensive stall feeding

18.6 Left in outdoor paddock and fed fodder and crop residues

18.7 Semi-intensive with limited grazing

18.8 Integration with plantation crops

18.9 Males and females graze together

18.10 Males and females graze separately

18.11 Other (specify)

19. Kids/lambs

19.1 Intensive stall feeding

19.2 Run with their mothers

19.3 Left in outdoor paddocks

19.4 Tethering

19.5 Other (specify).

20/21 Non-cropping and dry seasons (September to February)

20. Adults

20.1 Extensive production

20.2 Semi-extensive

20.3 Semi-intensive with limited grazing

20.4 Tethering

20.5 Herding

20.6 Intensive production

20.7 Other (specify)

21. Kids/lambs

21.1 Run with their mothers

21.2 Intensive production

21.3 Tethering

21.4 Other (specify)

22. If you indicated tethering as a system of management you practice, give the options.

22.1 Tethered animal left continuously in same location throughout the day.

22.2 Location changed several times during the day.

22.3 Location changed each day.

23. If location is changed during the day, give number of times moved on average.

24. Length of tether

25. Local pastures commonly utilized by your animals

25.1 Amaranthus ("green")

25.2 Aspelia sp. ("awawa")

25.3 Sporobolus ("chung")

25.4 *Melinis minutiflora* ("oil of dog")

25.5 Imperata contortus ("spear grass")

25.6 Panicum maximum (guinea grass)

25.7 Pennisetum purpureum (elephant grass)

27.8 *Brachiaria* sp.

25.9 Kikuyu

25.10 Tripsacum laxum (guatemala grass)

25.11 Fodder trees (give names)

25.12 Other (specify)

26. Crops you grow whose by-products are fed to your animals

26.1 Maize

26.2 Cassava

26.3 Groundnuts

26.4 Beans

26.5 Millet

26.6 Sorghum

26.7 Cotton

26.8 Rice

26.9 Bananas/Plantains

26.10 Other (specify)

27. Reaction of your neighbours when your animals are on free range (extensive production)

27.1 Tolerate it unconditionally

27.2 Do not tolerate it

27.3 Tolerate it provided the animals are herded

27.4 Tolerate it only during non-cropping season

27.5 Other (specify)

28. Persons that assist you in looking after the animals

28.1 Unpaid family labour children

28.2 wife

28.3 relative

28.4 Paid labour (employed herdsman)

28.5 Other (specify)

29. Daily grazing schedule

	Rainy Season		Dry Season	
	Out	In	Out	In
29.1 6.00–8.00				
29.2 8.00–10.00				
29.3 10.00–12.00				
29.4 12.00–14.00				
29.5 14.00–16.00				
29.6 16.00–18.00				
29.7 18.00–20.00				
29.8 No consistent time				

30. How much grazing area do you have available for your animals?

30.1 Under 2 hectares

30.2 2–5 hectares

30.3 Above 5 hectares

30.4 No fixed limits

31. Do you practise mixed grazing (i.e. sheep and/or goats with cattle) Yes/No

32. Replacement policy

32.1 Entirely home reared

32.2 Purchase from known farmer

32.3 Purchase from local market

32.4 Purchase from Government or voluntary agency establishment

32.5 Other (specify)

HOUSING

33. Do you provide any form of housing for your animals?

33.1 Yes/No

33.2 If Yes, describe its structure, including some account of when it was constructed, who constructed it, its quality, its value and indicate if family labour and local materials were used.

If No, where do your animals stay at night?

33.3 Veranda of house in the neighbourhood

33.4 Night paddocks

33.5 Tethered near your house

33.6 Don't know

33.7 Other (specify)

34. If you have constructed fences for your animals please indicate the materials used.

34.1 Wooden posts

34.2 Iron posts

34.3 Sticks

34.4 Raffia bamboos

34.5 Barbed wire

34.6 Goat or sheep wire

34.7 Nails

34.8 Bamboo rope

34.9 Indian bamboos

34.10 Tree fern

34.11 Other (specify)

35. Are the bucks and rams housed separately from the does and ewes?

35.1 Yes/No

If No, how do you control breeding?

35.2 Male tethered when inside barn

35.3 Male grazed separately from females

35.4 No control

35.5 Other (specify)

36. Are the kids and lambs housed with the adults?

Yes/No

FEEDING

37. In addition to the forage obtained from the pastures, what other feed items are utilised by your animals?

Crop by-products

37.1 Sweet potato vines

37.2 Groundnut vines

37.3 Bean stems

37.4 Corn stovers

37.5 Sugar cane tops

37.6 Cassava leaves

37.7 Plantain and banana leaves

37.8 Sweet potato roots and tubers

37.9 Cassava root and tubers

37.10 Other (specify)

Houshold wastes

37.11 Peelings of banana, plantains

37.12 Cocoyams, cassava, yams etc.

37.13 Remains of cooked food

37.14 Other (specify)

Concentrates

37.15 Rice bran

37.16 Cottonseed cake

37.17 Groundnut cake

37.18 Brewer's dried grain

37.19 Corn

37.20 Other (specify)

37.21 Mineral mix

37.22 Common salt

37.23 Other (specify)

38. Do you provide your animals any feed after you've locked them up for the night?

38.1 Yes/No

If Yes, what?

38.2 Hay

38.3 Fodder

38.4 Concentrate

38.5 Other (specify)

If Yes, under what circumstances do you provide the feed?

38.6 During the dry season

38.7 When the animal is sick

38.8 During heavy rains

38.9 Other (specify)

39. Do you feed concentrates to the following groups of animals?

Pregnant does and ewes	Yes/No
Lactating does and ewes	Yes/No
Unweaned kids and lambs	Yes/No
Weaned kids and lambs	Yes/No
Breeding bucks and rams	Yes/No
Breeding herd	Yes/No
All the flock	Yes/No

40. Do you provide your animals drinking water?

40.1 Yes/No

IF Yes, how often?

40.2 Once a day

40.3 Twice a day

40.4 Every other day

40.5 Don't know

40.6 Other (specify)

40.7 If No, how do they obtain water? (specify)

40.8 How far do they walk to take water (in km)

41. What containers do you use in providing feed and water to your animals?

Feed

41.1 Metal feeders

41.2 Bucket or basin

41.3 Wooden trough

41.4 Bamboo trough

41.5 Tray

41.6 Other (specify)

Water

41.7 Bucket or basin

41.8 Indian bamboo trough

41.9 Metal drinkers

41.10 Other (specify)

How often do you clean these containers?

41.11 Once a day

41.12 Once in two days

41.13 Once a week

41.14 Twice a week

41.15 Other (specify)

BREEDING AND CARE OF THE YOUNG

42. Do you have your own buck or ram?

42.1 Buck Yes/No

42.2 Ram Yes/No

43. Do you have a male with the female all the time?

43.1 Sheep Yes/No

43.2 Goat Yes/No

44/45 Age at first service 44. Sheep 45. Goat

1. Under 10 months
2. 10–15 months
3. 15–20 months
4. Above 20 months
5. Don't know

Have you observed any breed differences?

44.6 Sheep Yes/No/Don't know

45.6 Goat Yes/No/Don't know

If Yes, specify

46.1 Sheep

46.2 Goat

47/48 Age of doe or ewe at first kidding or lambing

47. Sheep 48. Goats

1. Under 10 months
2. 10–15 months
3. 15–20 months
4. 20–24 months
5. Above 24 months
6. Don't know

49. Have you observed any breed differences?

49.1 Sheep Yes/No/Don't know

49.2 Goat Yes/No/Don't know

If Yes, specify

50.1 Sheep

50.2 Goat

51/52 How often do your animals kid or lamb?

51. Sheep 52. Goats

1. Once a year
2. Twice a year
3. Thrice in two years
4. Once in two years
5. Don't know

Any breed differences?

51.6 Sheep Yes/No/Don't know

52.6 Goats Yes/No/Don't know

If Yes, specify

53.1 Sheep

53.2 Goats

54/55 Indicate in order of increasing frequency the occurrence of single births, twins and triplets in your flock

54. Sheep 55. Goats

1. Singles - twins - triplets
2. Singles - triplets - twins
3. Twins - singles - triplets
4. Twins - triplets - singles
5. Triplets - singles - twins

6. Triplets - twins - singles

Any breed differences?

54.7 Sheep Yes/No/Don't know

55.7 Goats Yes/No/Don't know

If Yes, specify

56.1 Sheep

56.2 Goats

57/58 Age at weaning 57. Sheep 58. Goats

1. Under 3 months
2. 3 months
3. 4-6 months
4. Above 6 months
5. Don't know

59/60 Do you castrate the bucks or rams you do not intend to keep for breeding?

59.1 Rams Yes/No

60.1 Bucks Yes/No

If Yes, at what age? 59. Rams 60. Bucks

2. Under 2 weeks
3. 2-4 weeks
4. Above 4 weeks

61/62 Ratio of does and ewes to bucks and rams?

61. Sheep 62. Goats

1. One male to 10 females
2. One male to 10-20 females
3. One male to 20-40 females
4. One male to more than 40 females
5. Don't know

HEALTH CONTROL

63/64 How many sheep and goats died in your flock between January 1, 1984 and December 31, 1984.

63.1 Sheep

64.1 Goats

65/66 Of those animals that died, how many died:-

65. Sheep 66. Goats

1. Between birth and 1 week of age?
2. Between 1 week and 1 month of age?
3. Between 1 month and 6 months of age?
4. Between 6 months and 1 year of age?
5. Over 1 year of age?
6. Total

67/68 How many animals from your flock were slaughtered between January 1, 1984 and December 31, 1984

67. Sheep 68. Goats

1. Ewes or does
2. Rams or bucks
3. Castrates
4. Lambs or kids
5. Don't know

Of these how many were sick at the time of slaughter?

6. Ewes or does
7. Rams or bucks
8. Castrates
9. Lambs or kids
10. Don't know

69/70 How many animals have been sold during the same period?

69. Sheep 70. Goats

1. Ewes or does
2. Rams or bucks
3. Castrates
4. Lambs or kids
5. Don't know

71-72. How many animals left your flock for any other reason during this period?

71. Sheep 72. Goats

1. Ewes or does
2. Rams or bucks

3. Castrates
4. Lambs or kids
5. Don't know

For what reason(s) did they leave your flock (state briefly)?

71.6 Sheep

72.6 Goats

73-74. How many animals have joined your flock from elsewhere during the period January 1, 1984 to December 31, 1984.

73. Sheep 74. Goats

1. Lambs or kids
2. Ewes or does
3. Rams or bucks
4. Castrates
5. Don't know

75-82. List in order of importance the four important diseases of sheep and goats in your flock.

Sheep	Goats
75	79
76	80
77	81
78	82

From the four diseases you've mentioned as important, please answer the following:-

	Sheep diseases				Goat diseases			
	75	76	77	78	79	80	81	82
How many animals suffered from the disease during 1984?								
How many animals died from the disease during this period?								

What groups of animals
are involved.
All stock
Kids/lambs
Ewes and does
Rams and bucks

When did the
disease occur?
Rainy season
Dry season

83-84. How serious were the following syndromes and signs which affected sheep and goats in your flock during the period January 1, 1984 to December 31, 1984 (Not observed, Mild, Fair or Bad)

83. Severity in sheep 84. Severity in goats

1. Depression
2. Loss of appetite
3. Sudden death
4. Diarrhoea
5. Coughing
6. Anaemia
7. Nasal discharge
8. Abortion
9. Kidding or lamb-
ing difficulties
10. Mastitis
11. Lameness
12. Pink eye
13. Salivation and
foaming at mouth
14. Vesicles in mouth
and feet
15. Sores in and around
lips
16. Pot belly
17. Swelling under jaw
18. Emaciation

19. Nervous symptoms
20. Unthriftiness
21. Presence of ticks
22. Presence of lice
23. Mange

85-86. Of the total number of deaths in your flock during January 1, 1984 to December 31, 1984 how many died of any of the diseases listed above?

	85. Sheep		86. Goats	
	Disease	No. of deaths	Disease	No. of deaths
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				

87-88. What other causes of death in your flock during this period are not mentioned in the list?

	87. Sheep	88. Goats
1.		
2.		
3.		
4.		

89. How far is the nearest veterinary office from your home?

89.1 Less than 1 kilometre
89.2 1 to 3 kilometres
89.3 3 to 5 kilometres
89.4 5 to 10 kilometres
89.5 More than 10 kilometres

90. How regularly do you use the veterinary services in your locality?

90.1 Only when there is a serious disease problem

90.2 Just occasionally

90.3 In all cases of disease

90.4 Not at all

90.5 Other (specify)

91. Do you sometimes administer traditional treatment to your sick animals? Yes/No

92. From where do you get your supply of veterinary drugs?

92.1 Veterinary Department

92.2 Veterinary Pharmacy (O.P.V.)

92.3 Commercial source

92.4 Other (specify)

93. If you give your animals any prophylactic treatment against worm infection, please indicate schedule of administration of anthelmintic.

93.1 Drug administered at fixed intervals (specify)

93.2 Strategic administration of anthelmintic when disease is anticipated

93.3 Tactical administration of anthelmintic in face of disease

93.4 Other (specify)

94. Schedule for cleaning the floor of the building or area where your animals spend the night

94.1 Daily

94.2 Once a week

94.3 Several times a week

94.4 Once in two weeks

94.5 Once in 2-4 weeks

94.6 Only occasionally

94.7 None of the above

95. If the floor is slatted, do you sweep off the faeces from under the building?

95.1 Yes/No

If Yes, give the schedule

95.2 Once a week

95.3 Several times a week

95.4 Once in two weeks

95.5 Once in 2-4 weeks

95.6 Only occasionally

95.7 Other (specify)

MARKETING AND RECORDS

96. What percentage of your cash income is provided by the sheep and/or goats you own?

96.1 Less than 10%

96.2 10-25%

96.3 25-50%

96.4 Above 50%

96.5 Don't know

97. Where do you go to sell your animals?

97.1 Local market

97.2 In the big towns or cities

97.3 Sold at home

97.4 Other (specify)

98. Principal buyers

98.1 Butchers

98.2 Middlemen (itinerant buyers)

98.3 Other farmers

98.4 Consumers

98.5 Other (specify)

99. How do you transport your animals to the place where they are to be sold?

99.1 Trekking

99.2 Pay truck or other form of vehicle

99.3 Personal transport (specify)

99.4 Other (specify)

100. Do you keep any records on your animals?

100.1 Yes/No

If Yes, on which of these topics are records available.

100.2 Production

100.3 Breeding

100.4 Mortality

100.5 Sales

100.6 Disease and medication

100.7 Other (specify)

APPENDIX 2B

BACKGROUND STUDIES ON TRADITIONALLY MANAGED SHEEP AND GOATS

IN THE NORTH WEST PROVINCE OF CAMEROON

IIb. General Questionnaire for Small Ruminant Farmers

1. Describe each management system you practice.
2. What factors are important in determining your goat/sheep keeping systems? (e.g. farm size, population density, climate, cropping patterns, market access etc.).
3. At what times of the year are you busiest? What are your main activities at the time and how do these affect your management of sheep and goats (e.g. frequency of watering, movement of tethered animals, cleaning out of sheds etc.)?
4. What are the main risks you face in your sheep/goat production?
5. What are the main contraints limiting your decisions and freedom of action regarding your sheep and goats?
6. How important is variability and uncertainty in income from your sheep/goat enterprise (e.g. arising from disease or production problems) to you and what effect do they have on your farm practices?

APPENDIX 3

DATA FOR THE BEGINNING OF NOVEMBER 1984

GROUP	SPECIES	NUMBER	AGE/ SEX	WEIGHT (Kg)	FAECAL EPG (x10)
S	S	25	L	6.00	0
S	S	17	L	6.25	0
S	S	11	L	7.50	0
S	S	16	L	8.00	0
S	S	6	L	9.50	0
S	S	84-08	E	17.50	0
S	S	1-261	E	19.00	0
S	S	81-64	E	20.00	0
S	S	81-68	E	20.50	0
S	S	82-27	E	21.75	0
S	S	81-71	E	22.00	0
S	S	82-23	E	22.25	0
S	S	82-33	E	22.00	0
S	S	81-58	E	22.75	0
S	S	84-10	E	23.75	0
S	S	82-26	E	21.00	0
S	S	284	R	17.50	0
S	S	329	R	19.50	0
S	S	307	R	20.50	0
S	S	84-09	R	25.00	0
S	S	84-11	R	29.25	0
R	S	23	L	6.50	0
R	S	7	L	7.00	0
R	S	14	L	7.00	0
R	S	30	L	8.00	0
R	S	22	L	9.00	0
R	S	1-266	E	17.75	0
R	S	82-34	E	19.50	0
R	S	82-14	E	20.00	0
R	S	81-54	E	20.25	0
R	S	81-52	E	21.75	0
R	S	81-72	E	21.50	0
R	S	81-73	E	22.25	0
R	S	1-267	E	22.00	0
R	S	81-59	E	23.00	0
R	S	81-55	E	23.75	0
R	S	81-51	E	23.00	0
R	S	273	R	17.00	0
R	S	81-03	R	19.00	0
R	S	344	R	19.25	0
R	S	1-269	R	26.50	0
R	S	334	R	30.50	0
T	S	26	E	26.00	20
T	S	27	E	25.00	140
T	S	28	E	31.25	80
T	S	29	E	28.50	105
T	S	30	R	28.00	10
T	S	31	E	20.00	1
T	S	32	R	31.25	35
T	S	33	L	15.00	25
T	S	47	L	14.00	50
T	S	35	L	14.00	130
T	S	36	E	29.25	25
T	S	37	E	22.50	15
T	S	38	L	14.50	40
T	S	39	R	34.50	5
T	S	40	E	24.25	70
T	S	41	E	25.25	20
T	S	42	L	8.25	525
T	S	43	L	6.75	206
T	S	44	L	15.00	445
T	S	46	L	11.50	230
T	S	50	L	6.75	206
T	S	84-32	K	6.50	0
S	G	84-18	K	8.00	0
S	G	185	K	9.00	0
S	G	214	K	10.50	0
S	G	49	K	12.00	0
S	G	217	K	12.00	0
S	G	204	K	13.00	0
S	G	6	K	13.50	0
S	G	145	K	13.50	0
S	G	201	K	14.00	0
S	G	184	D	14.50	0
S	G	104	D	15.00	0
S	G	39	D	17.50	0
S	G	193	B	18.00	0
S	G	107	D	19.00	0
S	G	110	D	20.00	0
S	G	146	D	21.50	0
S	G	140	D	24.00	0
S	G	121	D	25.00	0
S	G	125	D	26.00	0
R	G	84-15	K	7.50	0
R	G	210	K	8.00	0
R	G	215	K	8.50	0
R	G	192	K	11.00	0
R	G	216	K	11.50	0
R	G	213	K	12.00	0
R	G	183	K	12.50	0
R	G	194	K	13.00	0
R	G	202	K	13.50	0
R	G	117	K	14.00	0
R	G	111	D	17.00	0
R	G	15	B	16.50	0
R	G	127	D	17.50	0
R	G	122	B	17.50	0
R	G	144	D	18.00	0
R	G	137	D	20.50	0
R	G	105	D	22.50	0
R	G	130	D	23.50	0
R	G	115	D	25.00	0
R	G	101	D	25.50	0
T	G	1	D	16.25	125
T	G	2	K	10.63	265
T	G	3	D	24.00	105
T	G	4	D	20.75	75
T	G	5	D	14.00	345
T	G	6	D	20.00	35
T	G	7	D	17.50	240
T	G	8	D	19.25	95
T	G	9	B	16.25	100
T	G	10	K	6.25	153
T	G	11	K	3.25	250
T	G	12	K	4.00	1100
T	G	13	D	22.25	130
T	G	14	D	27.25	35
T	G	15	B	12.50	190
T	G	16	K	12.00	220
T	G	17	K	12.50	65
T	G	18	D	30.50	10
T	G	19	D	24.00	60
T	G	20	K	10.50	115
T	G	21	K	15.50	175
T	G	22	K	11.00	110
T	G	24	K	10.75	260
T	G	25	K	8.50	980

APPENDIX 3

DATA FOR MID-NOVEMBER 1984

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	6.50	0.00
S	S	17	L	6.50	0.00
S	S	11	L	8.00	1.50
S	S	16	L	9.00	0.00
S	S	6	L	10.25	0.00
S	S	84-08	E	19.25	5.50
S	S	1-261	E	20.75	4.50
S	S	81-64	E	21.50	72.00
S	S	81-68	E	22.50	42.00
S	S	82-27	E	23.75	3.50
S	S	81-71	E	22.50	3.00
S	S	82-23	E	23.75	15.00
S	S	82-33	E	24.25	0.00
S	S	81-58	E	25.75	5.50
S	S	84-10	E	20.00	1.00
S	S	82-26	E	22.75	0.12
S	S	284	R	17.00	116.00
S	S	329	R	19.25	13.50
S	S	307	R	23.50	0.50
S	S	84-09	R	25.25	255.00
S	S	84-11	R	27.50	98.00
R	S	23	L	7.00	0.00
R	S	7	L	7.75	0.50
R	S	14	L	7.50	0.07
R	S	30	L	9.00	0.50
R	S	22	L	10.50	1.50
R	S	1-266	E	18.00	9.00
R	S	82-34	E	19.25	5.50
R	S	82-14	E	20.75	2.00
R	S	81-54	E	21.00	4.50
R	S	81-52	E	23.00	0.00
R	S	81-72	E	21.50	33.00
R	S	81-73	E	23.00	8.00
R	S	1-267	E	23.00	0.01
R	S	81-59	E	23.00	8.50
R	S	81-55	E	25.25	10.50
R	S	81-51	E	23.00	3.50
R	S	273	R	15.00	104.50
R	S	81-03	R	16.75	25.50
R	S	344	R	18.25	24.00
R	S	1-269	R	24.75	32.50
R	S	334	R	28.25	14.00
T	S	26	E	26.50	9.00
T	S	27	E	21.50	10.50
T	S	28	E	29.00	11.00
T	S	29	E	28.50	9.00
T	S	31	E	20.50	4.50
T	S	33	R	16.00	10.50
T	S	47	L	14.75	2.00
T	S	35	L	14.25	11.50
T	S	36	E	28.50	3.50
T	S	37	E	22.50	0.13
T	S	38	L	15.75	1.50
T	S	39	R	34.00	1.00
T	S	40	E	25.50	2.00
T	S	41	E	25.50	3.00
T	S	42	L	9.00	7.00
T	S	43	L	7.50	3.00
T	S	44	L	0.00	-
T	S	45	L	16.25	3.50
T	S	46	L	12.50	11.50
T	S	50	L	8.00	3.00
S	G	84-32	K	6.50	0.00
S	G	84-18	K	7.75	0.03
S	G	185	K	9.00	0.50
S	G	214	K	10.00	1.00
S	G	49	K	11.00	0.50
S	G	217	K	12.75	0.50
S	G	204	K	13.25	0.03
S	G	6	K	13.75	0.00
S	G	145	K	13.75	1.00
S	G	201	K	13.25	0.20
S	G	184	D	15.00	0.04
S	G	104	D	15.25	0.00
S	G	39	D	18.00	0.00
S	G	193	B	19.00	0.01
S	G	107	D	19.50	1.00
S	G	110	D	21.00	0.03
S	G	146	D	18.75	0.00
S	G	140	D	25.00	0.00
S	G	121	D	26.50	0.00
S	G	125	D	24.00	0.00
R	G	84-15	K	8.25	0.00
R	G	210	K	8.25	0.04
R	G	215	K	9.00	0.50
R	G	192	K	10.75	0.50
R	G	216	K	11.25	1.50
R	G	213	K	11.50	0.00
R	G	183	K	13.25	0.00
R	G	194	K	13.00	0.50
R	G	202	K	14.25	0.50
R	G	117	K	15.00	0.00
R	G	111	D	14.75	0.00
R	G	15	B	16.50	0.01
R	G	127	D	16.25	0.00
R	G	122	B	17.75	0.50
R	G	144	D	18.00	0.50
R	G	137	D	21.00	0.50
R	G	105	D	22.75	0.03
R	G	130	D	25.00	1.00
R	G	115	D	25.50	0.00
R	G	101	D	25.75	0.00
T	G	1	D	18.00	5.50
T	G	2	K	12.00	1.00
T	G	3	D	26.50	1.50
T	G	4	D	22.75	4.00
T	G	5	D	14.75	6.00
T	G	6	D	21.50	4.00
T	G	7	D	19.50	4.50
T	G	8	D	21.50	6.50
T	G	9	B	17.00	3.00
T	G	10	K	7.50	1.00
T	G	11	K	0.00	-
T	G	12	K	4.00	6.00
T	G	13	D	22.75	13.50
T	G	14	D	26.50	3.50
T	G	15	B	13.00	11.00
T	G	16	K	13.00	2.50
T	G	17	K	13.25	2.50
T	G	18	D	29.00	2.00
T	G	19	D	26.50	2.50
T	G	20	K	10.75	1.50
T	G	21	K	15.25	10.50
T	G	22	K	10.75	12.00
T	G	24	K	11.00	7.50
T	G	25	K	8.50	-
T	G	48	D	24.50	-

APPENDIX 3

DATA FOR THE END OF NOVEMBER 1984

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	SERUM PEPSINOGEN (i.u.)
S	S	25	L	7.50	2.50	-	-	-	-	-	-	-	-
S	S	17	L	7.00	2.00	17.2	10.12	6.01	4.20	6.93	4.15	2.78	0.4170
S	S	11	L	9.00	4.50	2.7	21.16	8.55	7.00	7.10	4.60	2.50	0.6950
S	S	16	L	10.50	1.50	2.7	19.10	10.27	10.05	6.35	4.35	2.00	0.4170
S	S	6	L	12.00	0.00	27.5	20.65	7.30	14.10	6.93	5.18	1.75	0.4170
S	S	84-08	E	20.50	2.50	21.9	16.77	6.28	5.45	8.55	4.20	4.35	1.1120
S	S	1-261	E	20.50	0.05	19.5	15.17	6.00	7.10	7.85	4.20	3.65	0.4170
S	S	81-64	E	0.22	1.30	14.0	10.12	4.34	14.05	7.30	3.10	4.20	1.8070
S	S	81-68	E	23.50	2.50	30.5	22.71	8.15	10.60	9.10	4.20	4.90	0.9035
S	S	82-27	E	25.00	0.00	25.5	19.61	7.44	9.55	8.55	5.18	3.37	0.9035
S	S	81-71	E	24.00	0.04	19.1	14.97	6.40	11.90	8.20	3.70	4.50	1.3900
S	S	82-23	E	25.00	1.50	30.0	21.68	7.18	6.80	7.10	4.10	3.00	0.2780
S	S	82-33	E	26.00	0.00	29.9	23.43	8.25	10.95	7.30	3.25	4.05	0.6950
S	S	81-58	E	26.00	0.00	24.0	20.65	7.37	7.80	8.75	3.55	5.20	1.5985
S	S	84-10	E	21.00	1.00	23.0	18.06	6.15	8.85	7.10	4.05	3.05	0.2780
S	S	82-26	E	24.00	0.50	22.0	16.77	6.43	10.25	7.30	4.20	3.10	0.6950
S	S	284	R	17.50	5.50	23.0	13.42	7.45	8.95	7.10	3.40	3.70	0.4170
S	S	329	R	18.00	3.50	18.6	14.45	7.18	6.80	7.65	3.40	4.25	1.3900
S	S	307	R	24.00	12.50	23.1	15.17	5.08	10.95	6.93	3.55	3.38	0.6950
S	S	84-09	R	24.50	11.00	24.5	17.03	6.48	16.00	6.55	4.85	1.70	0.2780
S	S	84-11	R	27.00	2.50	21.5	15.48	7.52	8.45	7.10	4.10	3.00	1.3900
R	S	23	L	8.00	0.00	23.0	10.12	8.54	16.10	-	-	-	-
R	S	7	L	8.50	0.00	30.0	25.29	10.08	9.40	-	-	-	-
R	S	14	L	9.00	3.00	20.1	7.74	6.00	4.90	6.35	4.70	1.65	0.2780
R	S	30	L	10.50	1.50	25.5	20.65	9.14	13.75	6.55	3.30	3.25	0.4170
R	S	22	L	12.50	-	25.2	19.61	9.71	5.70	-	-	-	-
R	S	1-266	E	19.00	3.50	24.9	18.84	8.31	16.95	7.10	3.40	3.70	0.4170
R	S	82-34	E	21.00	2.60	16.0	0.00	-	9.60	6.93	4.30	2.63	1.1120
R	S	82-14	E	22.50	2.50	25.0	19.10	7.01	11.55	6.93	4.43	2.50	0.6950
R	S	81-54	E	23.50	5.00	23.0	16.52	6.86	9.35	6.55	2.60	3.95	0.9035
R	S	81-52	E	25.50	0.50	24.5	20.34	7.68	7.55	6.00	4.43	1.57	0.2780
R	S	81-72	E	23.00	4.00	20.0	15.17	5.86	13.85	6.35	3.55	2.80	0.0000
R	S	81-73	E	23.00	1.50	22.1	18.37	7.08	11.65	6.93	3.15	3.78	0.2780
R	S	1-267	E	25.00	0.00	32.0	25.81	10.24	7.80	7.10	4.30	2.80	1.5985
R	S	81-59	E	24.50	0.03	26.0	17.34	7.77	14.45	6.35	3.70	2.65	0.4170
R	S	81-55	E	25.50	0.50	27.0	18.58	8.15	10.90	6.20	4.20	2.00	0.2780
R	S	81-51	E	25.50	0.07	25.0	19.10	6.27	9.20	6.55	5.00	1.55	0.2780
R	S	273	R	15.00	7.50	12.0	8.77	5.71	18.25	5.83	3.00	2.83	0.4170
R	S	81-03	R	16.50	3.50	24.0	17.81	6.89	12.10	5.83	4.70	1.13	0.0000
R	S	344	R	19.00	2.00	24.1	19.87	9.36	8.30	6.55	4.05	2.50	0.6950
R	S	1-269	R	24.50	1.00	26.1	20.13	7.56	8.95	6.55	3.95	2.60	0.4170
R	S	334	R	31.50	4.00	25.5	19.61	4.78	8.60	6.75	4.05	2.70	1.1120
T	S	26	E	27.50	1.00	-	-	-	-	-	-	-	-
T	S	27	E	22.25	3.00	-	-	-	-	-	-	-	-
T	S	28	E	29.50	4.00	-	-	-	-	-	-	-	-
T	S	29	E	29.50	1.50	-	-	-	-	-	-	-	-
T	S	31	E	21.00	0.50	-	-	-	-	-	-	-	-
T	S	33	R	17.50	2.50	-	-	-	-	-	-	-	-
T	S	47	L	16.00	0.50	-	-	-	-	-	-	-	-
T	S	35	L	14.50	3.00	-	-	-	-	-	-	-	-
T	S	36	E	27.25	2.00	-	-	-	-	-	-	-	-
T	S	37	E	23.00	0.50	-	-	-	-	-	-	-	-
T	S	38	L	17.50	1.00	-	-	-	-	-	-	-	-
T	S	39	R	34.50	0.04	-	-	-	-	-	-	-	-
T	S	40	E	25.75	3.00	-	-	-	-	-	-	-	-
T	S	41	E	27.00	0.50	-	-	-	-	-	-	-	-
T	S	42	L	10.00	-	-	-	-	-	-	-	-	-
T	S	43	L	8.00	-	-	-	-	-	-	-	-	-
T	S	44	L	9.25	-	-	-	-	-	-	-	-	-
T	S	45	L	18.00	0.00	-	-	-	-	-	-	-	-
T	S	46	L	13.00	3.50	-	-	-	-	-	-	-	-
T	S	50	L	8.00	-	-	-	-	-	-	-	-	-
S	G	84-32	K	7.00	1.00	23.5	16.68	10.13	21.10	6.23	3.18	3.05	0.6950
S	G	84-18	K	8.25	1.00	21.2	16.00	11.07	19.20	6.95	3.83	3.12	0.4170
S	G	185	K	8.50	0.07	23.0	16.68	11.39	13.00	6.80	3.55	3.25	0.9040
S	G	214	K	10.00	1.00	19.2	12.12	6.53	14.40	6.60	3.30	3.30	0.4170
S	G	49	K	10.50	1.00	22.4	16.00	9.89	17.50	7.50	2.90	4.60	0.6950
S	G	217	K	12.25	3.50	31.0	21.33	17.79	18.25	7.70	3.65	4.05	0.6950
S	G	204	K	13.50	0.06	21.9	15.03	7.13	18.00	7.90	3.70	4.20	0.4170
S	G	6	K	13.00	0.00	33.9	21.33	13.61	20.40	7.15	3.95	3.20	0.4170
S	G	145	K	14.00	1.00	30.0	17.16	12.38	20.25	7.50	3.90	3.60	0.2780
S	G	201	K	13.25	0.50	16.2	12.61	7.18	16.30	6.95	3.10	3.85	0.6950
S	G	184	D	15.00	0.50	30.2	21.82	12.16	17.85	6.95	3.83	3.12	0.0000
S	G	104	D	14.25	0.00	25.5	18.91	12.74	13.95	7.15	2.13	5.02	0.0000
S	G	39	D	17.50	0.01	29.0	16.97	12.31	17.25	6.40	3.95	2.45	0.2780
S	G	193	B	19.25	0.03	28.8	24.73	11.98	12.35	7.70	4.10	3.60	0.0000
S	G	107	D	19.50	4.50	31.6	24.24	15.30	13.05	7.33	4.23	3.10	0.0000
S	G	110	D	21.00	0.50	27.2	19.88	12.48	12.15	6.03	3.18	2.85	0.2780
S	G	146	D	18.25	1.00	25.0	17.45	10.82	16.35	7.50	4.35	3.15	0.0000
S	G	140	D	25.00	1.50	35.0	14.06	13.32	17.20	7.33	3.45	3.88	0.0000
S	G	121	D	27.00	0.04	32.0	22.98	12.11	13.50	8.05	3.55	4.50	0.4170
S	G	125	D	21.50	0.14	29.1	21.33	10.75	22.60	8.60	4.23	4.37	0.0000
R	G	84-15	K	8.25	1.50	27.2	17.31	12.65	23.50	8.75	3.70	5.05	0.9040
R	G	210	K	8.50	1.00	20.0	9.36	6.85	12.00	8.20	3.18	5.02	0.9040
R	G	215	K	9.00	1.00	26.0	11.98	7.54	20.05	-	-	-	1.3900
R	G	192	K	11.00	1.50	22.5	12.16	10.16	18.75	8.55	3.70	4.55	0.9040
R	G	216	K	10.50	0.50	30.1	13.19	14.47	18.60	7.85	3.83	4.02	1.3900
R	G	213	K	11.25	0.50	32.5	19.46	11.11	25.30	7.30	3.55	3.75	1.1120
R	G	183	K	13.50	0.00	35.5	20.12	13.93	13.10	6.93	3.75	3.18	2.0850
R	G	194	K	12.50	0.50	29.0	14.78	13.50	12.70	7.10	3.83	3.27	1.3900
R	G	202	K	14.75	0.50	29.0	16.84	13.90	20.85	6.35	2.98	3.37	0.6950
R	G	117	K	14.00	1.00	29.1	15.72	12.25	15.50	7.10	3.55	3.55	0.6950
R	G	111	D	14.00	0.50	27.5	16.37	12.29	14.55	7.85	3.45	4.40	1.3900
R	G	15	B	15.25	0.00	27.0	16.37	12.13	15.85	7.30	3.55	3.75	0.6950
R	G	127	D	15.00	0.50	33.1	12.82	13.65	20.95	7.10	2.13	4.97	0.9040
R	G	122	B	17.00	1.00	31.7	19.65	14.05	14.80	6.93	3.65	3.28	0.4170
R	G	144	D	17.25	0.05	30.0	18.81	11.72	13.95	6.93	4.10	3.03	0.6950
R	G	137	D	16.00	1.00	29.0	12.63	12.83	16.15	6.93	3.90	3.03	1.3900
R	G	105	D	22.50	0.00	33.9	21.52	11.24	13.30	7.65	3.90	3.75	1.5990
R	G	130	D	20.00	2.00	34.1	18.15	13.03	16.70	7.85	3.70	4.15	1.8070
R	G	115	D	24.75	0.01	30.5	13.85	11.51	12.00	6.75	4.10	2.65	0.9040
R	G	101	D	22.50	0.03	34.0	17.31	11.58	21.40	8.03	3.70	4.33	0.9040
T	G	1	D	18.75	0.01	-	-	-	-	-	-	-	-
T	G	2	K	12.50	-	-	-	-	-	-	-	-	-
T	G	3	D	27.75	0.04	-	-	-	-	-	-	-	-
T	G	4	D	23.50	3.00	-	-	-	-	-	-	-	-
T	G	5	D	14.75	1.50	-	-	-	-	-	-	-	-
T	G	6	D	21.50	0.50	-	-	-	-	-	-	-	-
T	G	7	D	20.00	0.50	-	-	-	-	-	-	-	-
T	G	8	D	22.50	0.50	-	-	-	-	-	-	-	-
T	G	9	B	17.25	1.00	-	-	-	-	-	-	-	-
T	G	10	K	8.75	-	-	-	-	-	-	-	-	-
T	G	11	K	4.25	-	-	-	-	-	-	-	-	-
T	G	12	K	4.50	1.00	-	-	-	-	-	-	-	-
T	G	13	D	23.75	1.00	-	-	-	-	-	-	-	-
T	G	14	D	29.25	1.00	-	-	-	-	-	-	-	-
T	G	15	B	14.50	1.50	-	-	-	-	-	-	-	-
T	G	16	K	13.00	1.00	-	-	-	-	-	-	-	-
T	G	17	K	13.25	0.00	-	-	-	-	-	-	-	-
T	G	18	D	30.75	0.00	-	-	-	-	-	-	-	-
T	G	19	D	27.50	0.00	-	-	-	-	-	-	-	-
T	G	20	K	10.75	2.50	-	-	-	-	-	-	-	-
T	G	21	K	14.50	5.00	-	-	-	-	-	-	-	-
T	G	22	K	12.00	0.50	-	-	-	-	-	-	-	-
T	G	24	K	12.00	1.50	-	-	-	-	-	-	-	-
T	G	25	K	9.00	-	-	-	-	-	-	-	-	-
T	G	48	D	24.75	-	-	-	-	-	-	-	-	-

APPENDIX 3

DATA FOR MID-DECEMBER 1984

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	8.75	0.00
S	S	17	L	7.50	0.00
S	S	11	L	10.00	0.00
S	S	16	L	12.50	0.00
S	S	6	L	13.50	0.01
S	S	84-08	E	23.75	0.01
S	S	1-261	E	22.50	0.50
S	S	81-64	E	24.50	-
S	S	81-68	E	25.50	4.50
S	S	82-27	E	27.50	0.00
S	S	81-71	E	25.50	0.01
S	S	82-23	E	27.00	1.00
S	S	82-33	E	28.50	0.00
S	S	81-58	E	28.00	0.00
S	S	84-10	E	23.00	0.50
S	S	82-26	E	25.50	0.00
S	S	284	R	21.00	4.50
S	S	329	R	20.25	0.00
S	S	307	R	23.25	11.50
S	S	84-09	R	26.50	18.00
S	S	84-11	R	30.50	9.00
R	S	23	L	8.50	0.00
R	S	7	L	9.50	0.00
R	S	14	L	11.00	0.00
R	S	30	L	11.00	0.01
R	S	22	L	14.50	2.50
R	S	1-266	E	21.50	2.50
R	S	82-34	E	22.50	3.00
R	S	82-14	E	24.50	0.00
R	S	81-54	E	25.75	0.50
R	S	81-52	E	26.00	0.00
R	S	81-72	E	25.50	0.50
R	S	81-73	E	25.00	0.00
R	S	1-267	E	25.00	0.00
R	S	81-59	E	24.50	0.00
R	S	81-55	E	27.50	0.05
R	S	81-51	E	27.50	0.50
R	S	273	R	16.75	8.00
R	S	81-03	R	17.00	0.50
R	S	344	R	21.00	0.50
R	S	1-269	R	27.50	0.00
R	S	334	R	32.50	0.50
T	S	26	E	28.00	1.00
T	S	27	E	21.25	7.00
T	S	28	E	28.75	4.50
T	S	29	E	29.00	3.50
T	S	31	E	22.25	3.00
T	S	33	R	16.75	0.50
T	S	47	L	16.50	3.50
T	S	35	L	17.25	2.00
T	S	36	E	24.50	1.00
T	S	37	E	23.75	0.11
T	S	38	L	17.50	0.50
T	S	39	R	34.50	0.01
T	S	40	E	25.50	2.50
T	S	41	E	27.00	1.00
T	S	42	L	10.50	1.00
T	S	43	L	9.00	0.50
T	S	44	L	9.40	-
T	S	45	L	18.00	0.50
T	S	46	L	14.75	3.50
T	S	50	L	8.50	-
S	G	84-32	K	7.00	0.03
S	G	84-18	K	8.50	0.07
S	G	185	K	9.00	0.50
S	G	214	K	9.75	1.50
S	G	49	K	9.50	0.05
S	G	217	K	13.00	0.07
S	G	204	K	13.50	0.50
S	G	6	K	12.75	0.00
S	G	145	K	14.00	0.00
S	G	201	K	12.25	0.01
S	G	184	D	15.50	0.00
S	G	104	D	14.75	0.01
S	G	39	D	18.25	0.00
S	G	193	B	18.50	0.50
S	G	107	D	19.00	0.50
S	G	110	D	20.75	0.01
S	G	146	D	18.00	0.05
S	G	140	D	25.50	0.04
S	G	121	D	26.75	0.03
S	G	125	D	21.50	0.00
R	G	84-15	K	8.25	0.00
R	G	210	K	8.25	0.03
R	G	215	K	9.00	0.08
R	G	192	K	11.00	0.03
R	G	216	K	11.25	0.04
R	G	213	K	11.50	0.00
R	G	183	K	14.00	0.01
R	G	194	K	13.00	0.50
R	G	202	K	14.50	0.01
R	G	117	K	14.00	0.50
R	G	111	D	14.00	0.11
R	G	15	B	15.75	0.03
R	G	127	D	14.75	0.07
R	G	122	B	17.50	0.50
R	G	144	D	18.00	0.00
R	G	137	D	17.25	0.00
R	G	105	D	24.25	0.50
R	G	130	D	20.00	1.00
R	G	115	D	26.25	0.00
R	G	101	D	22.50	0.03
T	G	1	D	20.00	0.50
T	G	2	K	12.50	0.50
T	G	3	D	30.50	0.00
T	G	4	D	25.25	-
T	G	5	D	16.25	0.00
T	G	6	D	22.75	0.50
T	G	7	D	-	2.00
T	G	8	D	-	-
T	G	9	B	18.50	1.00
T	G	10	K	9.50	0.00
T	G	11	K	4.75	1.00
T	G	12	K	5.00	0.01
T	G	13	D	30.25	0.50
T	G	14	D	28.25	0.50
T	G	15	B	15.25	1.00
T	G	16	K	13.25	1.50
T	G	17	K	15.75	0.01
T	G	18	D	32.00	0.50
T	G	19	D	31.25	1.00
T	G	20	K	11.25	0.12
T	G	21	K	-	-
T	G	22	K	14.00	0.09
T	G	23	D	-	3.00
T	G	24	K	14.00	2.50
T	G	25	K	10.00	12.00
T	G	48	D	23.50	3.00

APPENDIX 3

DATA FOR THE END OF DECEMBER 1984

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	HD G%	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	SERUM PEPSINOGEN (i.u.)
S	S	25	L	9.50	0.03	25.0	16.64	7.45	3.40	4.05	0.5560
S	S	17	L	8.25	1.00	23.5	17.49	6.35	3.10	3.25	0.5560
S	S	11	L	11.00	1.50	28.0	17.07	6.00	3.80	2.20	0.2780
S	S	16	L	13.50	0.50	29.5	18.35	6.00	3.95	2.05	0.5560
S	S	6	L	14.00	0.00	28.5	17.20	6.35	4.35	2.00	0.2780
S	S	84-08	E	23.50	0.00	29.0	19.20	7.10	3.80	3.30	0.6950
S	S	1-261	E	23.50	0.00	15.5	16.00	7.10	3.80	3.30	0.1390
S	S	81-64	E	22.50	4.50	23.0	15.36	8.03	2.60	5.43	1.3900
S	S	81-68	E	26.00	3.50	31.5	21.33	8.20	3.65	4.55	0.2780
S	S	82-27	E	27.50	0.01	28.5	20.48	-	-	-	0.4170
S	S	81-71	E	25.00	0.20	24.0	16.43	7.45	3.10	4.35	0.5560
S	S	82-23	E	27.00	0.05	34.0	16.64	7.45	2.93	4.52	0.5560
S	S	82-33	E	29.50	0.00	30.0	20.91	7.10	4.35	2.75	0.2780
S	S	81-58	E	29.50	0.00	20.0	16.84	7.85	3.95	3.90	1.1120
S	S	84-10	E	22.50	-	25.5	17.92	7.10	3.15	3.95	0.9730
S	S	82-26	E	25.00	0.01	20.0	17.68	6.75	4.10	2.65	0.4170
S	S	284	R	21.75	5.50	22.5	17.26	6.75	3.10	3.65	1.1120
S	S	329	R	20.00	3.00	22.0	16.21	6.93	2.35	4.58	0.5560
S	S	307	R	22.25	1.50	28.0	19.20	7.10	3.65	3.45	0.4170
S	S	84-09	R	28.00	0.50	24.0	23.47	6.75	3.65	3.10	0.9730
S	S	84-11	R	31.50	2.00	23.5	18.95	7.10	3.65	3.45	0.8340
R	S	23	L	9.50	1.00	22.5	16.64	7.85	3.30	4.55	0.6950
R	S	7	L	9.75	0.00	18.0	16.21	6.55	4.10	2.45	0.1390
R	S	14	L	11.00	0.01	31.0	20.48	7.10	4.43	2.67	0.4170
R	S	30	L	11.75	0.50	23.5	19.20	7.10	3.80	3.30	0.2780
R	S	22	L	14.50	0.04	31.0	15.36	7.30	3.95	3.35	0.1390
R	S	1-266	E	21.50	1.50	28.0	20.48	7.10	4.10	3.00	0.2780
R	S	82-34	E	21.50	1.00	26.5	19.37	7.45	3.70	3.75	0.1390
R	S	82-14	E	24.75	1.00	24.0	18.99	8.20	3.65	4.55	1.1120
R	S	81-54	E	25.00	1.00	25.0	18.56	7.30	3.45	3.85	0.2780
R	S	81-52	E	27.00	0.00	25.0	17.92	6.75	3.30	3.45	0.6950
R	S	81-72	E	26.00	2.00	20.5	13.87	7.45	2.75	4.70	0.4170
R	S	81-73	E	27.00	0.50	28.0	17.92	7.65	3.30	4.35	0.4170
R	S	1-267	E	25.00	2.50	31.0	22.74	8.20	4.10	4.10	0.4170
R	S	81-59	E	26.50	0.00	24.0	18.77	7.45	2.75	4.70	0.0000
R	S	81-55	E	27.75	0.00	29.0	19.20	6.75	2.93	3.82	0.4170
R	S	81-51	E	27.00	1.50	24.0	16.21	7.10	4.10	3.00	0.2780
R	S	273	R	16.50	2.00	21.0	17.92	6.75	2.93	3.83	0.1390
R	S	81-03	R	19.00	5.00	25.0	18.77	6.35	3.15	3.20	0.5560
R	S	344	R	20.50	0.08	25.0	15.36	7.85	3.00	4.85	0.4170
R	S	1-269	R	27.75	0.00	28.5	20.69	7.85	3.65	4.20	0.5560
R	S	334	R	33.00	0.12	28.0	21.89	7.85	3.45	4.40	0.5560
T	S	26	E	27.50	3.00	-	-	-	-	-	-
T	S	27	E	22.25	2.50	-	-	-	-	-	-
T	S	28	E	28.50	1.50	-	-	-	-	-	-
T	S	29	E	28.75	1.50	-	-	-	-	-	-
T	S	31	E	20.50	0.50	-	-	-	-	-	-
T	S	33	R	16.50	-	-	-	-	-	-	-
T	S	47	L	15.00	1.50	-	-	-	-	-	-
T	S	35	L	15.25	1.00	-	-	-	-	-	-
T	S	36	E	26.00	1.50	-	-	-	-	-	-
T	S	37	E	24.75	0.50	-	-	-	-	-	-
T	S	38	L	18.00	1.00	-	-	-	-	-	-
T	S	39	R	35.00	1.00	-	-	-	-	-	-
T	S	40	E	23.00	-	-	-	-	-	-	-
T	S	41	E	24.00	1.00	-	-	-	-	-	-
T	S	42	L	11.50	1.50	-	-	-	-	-	-
T	S	43	L	9.50	0.01	-	-	-	-	-	-
T	S	44	L	10.25	-	-	-	-	-	-	-
T	S	45	L	18.50	1.00	-	-	-	-	-	-
T	S	46	L	14.50	6.00	-	-	-	-	-	-
T	S	50	L	9.00	1.50	-	-	-	-	-	-
S	G	84-32	K	7.00	0.01	19.0	15.74	6.35	2.53	3.82	0.0973
S	G	84-18	K	8.75	1.50	18.0	14.79	7.85	3.30	4.55	0.0556
S	G	185	K	9.75	1.00	20.0	18.42	7.88	3.45	4.43	1.1120
S	G	214	K	10.25	-	14.5	11.28	8.05	2.73	5.32	1.6680
S	G	49	K	9.25	0.00	13.5	17.00	8.03	2.30	5.73	0.4170
S	G	217	K	13.50	1.00	23.5	21.33	7.10	3.05	4.05	0.5560
S	G	204	K	14.50	1.00	19.0	15.25	7.30	3.25	4.05	0.9730
S	G	6	K	13.50	0.00	25.0	19.67	7.45	2.53	4.92	1.3900
S	G	145	K	14.50	0.00	22.5	15.74	7.10	2.58	4.52	0.6950
S	G	201	K	12.75	0.00	14.0	10.00	6.35	2.53	3.82	1.2510
S	G	184	D	15.75	0.00	25.5	20.90	7.10	3.05	4.05	0.8340
S	G	104	D	14.75	0.00	22.0	17.94	7.30	2.58	4.72	1.1120
S	G	39	D	19.25	1.50	22.0	21.94	5.65	2.78	2.87	1.9460
S	G	193	B	18.50	1.00	23.0	20.13	7.10	2.90	4.20	0.8340
S	G	107	D	20.50	1.50	23.0	20.39	7.10	2.25	4.85	0.6950
S	G	110	D	22.00	0.00	23.0	21.42	7.10	3.05	4.05	0.9730
S	G	146	D	19.00	1.00	21.0	15.45	7.30	3.70	3.60	0.8340
S	G	140	D	27.50	0.03	26.0	19.93	7.10	3.25	3.85	1.3900
S	G	121	D	27.50	0.50	24.0	18.36	6.75	2.98	3.77	0.8340
S	G	125	D	21.00	1.00	18.5	17.55	7.85	3.10	4.75	0.8340
R	G	84-15	K	8.50	1.00	21.0	14.03	8.93	2.90	6.03	0.6950
R	G	210	K	8.50	1.00	10.0	8.86	10.00	2.73	7.27	0.4170
R	G	215	K	9.50	1.50	24.5	15.51	8.03	-	-	0.8340
R	G	192	K	12.00	2.00	25.0	16.98	10.00	3.45	6.55	0.8340
R	G	216	K	11.75	1.50	20.5	12.07	8.20	2.73	5.47	0.8340
R	G	213	K	11.50	0.06	19.0	11.80	8.55	2.20	6.35	0.5560
R	G	183	K	15.00	0.03	30.0	16.98	8.20	3.55	4.65	1.8070
R	G	194	K	13.00	0.04	26.0	16.00	7.85	3.63	4.22	0.5560
R	G	202	K	15.25	0.50	29.0	17.48	7.85	2.85	5.00	0.8340
R	G	117	K	14.50	0.03	23.5	17.97	7.45	3.30	4.15	0.9730
R	G	111	D	14.50	0.50	26.0	17.48	8.75	2.58	6.17	1.1120
R	G	15	B	16.50	-	23.0	16.49	7.10	3.90	3.20	0.9730
R	G	127	D	15.00	0.50	23.0	15.48	7.85	3.30	4.55	1.1120
R	G	122	B	17.50	0.50	27.0	19.45	7.45	3.55	3.90	1.2510
R	G	144	D	17.50	0.50	18.0	18.95	7.45	3.50	3.95	0.9730
R	G	137	D	17.50	1.50	19.0	15.51	7.10	-	-	1.2510
R	G	105	D	23.75	0.50	26.0	24.62	6.93	3.50	3.43	1.8070
R	G	130	D	19.50	0.04	23.0	17.48	9.30	2.58	6.72	1.3900
R	G	115	D	26.00	1.00	27.0	18.71	7.65	3.35	4.30	1.5290
R	G	101	D	21.25	0.01	25.0	20.92	7.30	2.30	5.00	1.8070
T	G	1	D	21.00	0.03	-	-	-	-	-	-
T	G	2	K	12.75	0.00	-	-	-	-	-	-
T	G	3	D	26.50	0.50	-	-	-	-	-	-
T	G	4	D	24.00	3.50	-	-	-	-	-	-
T	G	5	D	16.75	0.00	-	-	-	-	-	-
T	G	6	D	23.50	0.50	-	-	-	-	-	-
T	G	7	D	23.75	1.00	-	-	-	-	-	-
T	G	8	D	22.75	2.00	-	-	-	-	-	-
T	G	9	B	19.00	0.01	-	-	-	-	-	-
T	G	10	K	10.25	0.00	-	-	-	-	-	-
T	G	11	K	-	-	-	-	-	-	-	-
T	G	12	K	MISSING	-	-	-	-	-	-	-
T	G	13	D	-	2.00	-	-	-	-	-	-
T	G	14	D	25.50	0.50	-	-	-	-	-	-
T	G	15	B	11.50	0.05	-	-	-	-	-	-
T	G	16	K	12.25	0.50	-	-	-	-	-	-
T	G	17	K	14.50	0.50	-	-	-	-	-	-
T	G	18	D	31.75	0.50	-	-	-	-	-	-
T	G	19	D	32.50	-	-	-	-	-	-	-
T	G	20	K	13.00	2.50	-	-	-	-	-	-
T	G	21	K	-	-	-	-	-	-	-	-
T	G	22	K	16.50	1.50	-	-	-	-	-	-
T	G	23	K	-	-	-	-	-	-	-	-
T	G	24	K	15.75	1.50	-	-	-	-	-	-
T	G	25	K	11.50	6.00	-	-	-	-	-	-

APPENDIX 3

DATA FOR MID-JANUARY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	9.50	4.00
S	S	17	L	8.50	1.00
S	S	11	L	11.50	3.50
S	S	16	L	14.25	1.50
S	S	6	L	14.50	0.50
S	S	84-08	E	23.50	0.00
S	S	1-261	E	23.00	0.00
S	S	81-64	E	21.50	12.00
S	S	81-68	E	26.00	3.00
S	S	82-27	E	28.00	3.00
S	S	81-71	E	24.50	1.00
S	S	82-23	E	27.50	0.50
S	S	82-33	E	29.25	0.50
S	S	81-58	E	28.75	0.03
S	S	84-10	E	22.75	10.00
S	S	82-26	E	24.50	1.00
S	S	284	R	22.00	8.50
S	S	329	R	21.00	2.50
S	S	307	R	23.00	7.00
S	S	84-09	R	28.00	2.50
S	S	84-11	R	31.50	9.00
R	S	23	L	8.00	3.00
R	S	7	L	9.50	3.00
R	S	14	L	10.75	1.50
R	S	30	L	12.50	6.00
R	S	22	L	15.25	2.50
R	S	1-266	E	21.50	20.00
R	S	82-34	E	21.25	6.50
R	S	82-14	E	24.75	1.00
R	S	81-54	E	24.75	2.00
R	S	81-52	E	28.75	1.00
R	S	81-72	E	25.00	3.00
R	S	81-73	E	26.50	3.50
R	S	1-267	E	25.75	1.50
R	S	81-59	E	26.00	2.00
R	S	81-55	E	28.00	0.03
R	S	81-51	E	26.00	4.00
R	S	273	R	18.50	17.50
R	S	81-03	R	20.00	10.50
R	S	344	R	21.25	7.00
R	S	1-269	R	29.00	14.50
R	S	334	R	33.50	9.00
S	G	84-32	K	7.00	0.00
S	G	84-18	K	8.50	0.00
S	G	185	K	10.00	0.00
S	G	214	K	10.75	0.00
S	G	49	K	9.50	0.00
S	G	217	K	13.00	0.12
S	G	204	K	14.50	0.04
S	G	6	K	14.00	0.00
S	G	145	K	14.50	0.01
S	G	201	K	11.50	0.50
S	G	184	D	15.75	0.07
S	G	104	D	15.25	0.00
S	G	39	D	19.00	1.00
S	G	193	B	18.50	1.50
S	G	107	D	20.25	2.00
S	G	110	D	22.50	0.11
S	G	146	D	18.50	0.00
S	G	140	D	26.00	0.50
S	G	121	D	27.50	1.00
S	G	125	D	21.25	0.03
R	G	84-15	K	8.50	2.00
R	G	210	K	DEAD	-
R	G	215	K	9.25	2.50
R	G	192	K	12.00	2.00
R	G	216	K	11.25	0.50
R	G	213	K	12.00	0.15
R	G	183	K	15.00	1.00
R	G	194	K	13.00	3.00
R	G	202	K	15.00	2.00
R	G	117	K	15.50	1.50
R	G	111	D	14.00	0.50
R	G	15	B	15.75	2.50
R	G	127	D	14.75	2.00
R	G	122	B	17.50	2.50
R	G	144	D	19.00	0.50
R	G	137	D	18.00	2.00
R	G	105	D	25.75	2.50
R	G	130	D	19.00	2.50
R	G	115	D	28.75	1.00
R	G	101	D	20.50	0.50

APPENDIX 3

DATA FOR THE END OF JANUARY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	PLASMA PEPSINOGE (i.u.)
S	S	25	L	10.50	1.50	20.5	8.27	6.25	2.85	3.40	0.4170
S	S	17	L	9.00	6.00	23.5	7.50	5.90	2.45	3.45	0.8340
S	S	11	L	11.00	4.00	25.0	6.46	6.25	3.10	3.15	0.6950
S	S	16	L	15.00	2.00	21.2	7.24	5.55	3.15	2.40	0.8340
S	S	6	L	14.50	1.00	25.5	8.53	6.25	3.45	2.80	0.8340
S	S	84-08	E	24.00	0.01	20.9	7.24	6.60	3.45	3.15	1.2510
S	S	1-261	E	22.50	0.00	19.0	6.21	6.60	2.85	3.75	0.6950
S	S	81-64	E	22.00	29.00	19.5	5.17	6.75	2.35	4.40	0.2780
S	S	81-68	E	26.00	4.50	25.5	8.27	6.75	3.70	3.05	0.4170
S	S	82-27	E	22.00	6.50	24.1	8.27	5.90	3.80	2.10	0.6950
S	S	81-71	E	24.00	0.04	21.0	6.85	7.30	2.85	4.45	0.8340
S	S	82-23	E	28.00	0.15	26.0	7.24	6.95	3.15	3.80	0.4170
S	S	82-33	E	29.75	0.03	26.0	8.27	6.25	2.85	3.40	0.5560
S	S	81-58	E	28.50	0.01	18.5	5.43	6.95	2.70	4.25	0.1390
S	S	84-10	E	23.00	12.00	21.5	6.85	6.75	2.70	4.05	0.2780
S	S	82-26	E	24.50	0.01	22.5	6.85	6.40	3.30	3.10	0.4170
S	S	284	R	22.50	13.50	22.2	7.24	6.75	2.93	3.82	0.1390
S	S	329	R	21.25	2.00	20.0	7.24	6.75	2.70	4.05	0.5560
S	S	307	R	23.50	3.00	22.5	7.24	6.75	3.00	3.75	0.6950
S	S	84-09	R	28.50	2.00	27.1	6.25	6.25	3.70	2.55	0.2780
S	S	84-11	R	33.00	6.50	26.5	8.27	6.75	3.80	2.95	0.2780
S	S	23	L	9.50	1.50	20.5	6.04	7.10	3.88	3.22	0.1390
S	S	7	L	9.50	3.00	15.9	4.83	6.05	4.10	1.95	0.0000
S	S	14	L	11.25	0.50	26.5	8.94	6.75	-	-	0.0000
S	S	30	L	12.00	4.50	21.9	6.76	7.68	3.40	4.28	0.0695
S	S	22	L	14.00	4.00	22.5	8.33	6.95	4.60	2.35	0.2780
S	S	1-266	E	21.00	3.50	22.5	8.69	7.10	3.40	3.70	0.4870
S	S	82-34	E	21.50	2.00	23.0	7.00	6.95	4.75	2.20	0.5560
S	S	82-14	E	24.25	2.00	21.0	7.00	6.95	3.55	3.40	0.5560
S	S	81-54	E	24.75	3.50	18.9	6.40	6.25	4.20	2.05	0.9730
S	S	81-52	E	27.50	-	21.2	7.00	5.90	4.30	1.60	0.2780
S	S	81-72	E	23.25	3.50	18.8	5.80	6.25	3.40	2.85	0.1390
S	S	81-73	E	27.50	0.50	22.5	7.00	6.60	4.35	2.25	0.6950
S	S	1-267	E	25.50	0.50	31.0	10.51	7.45	3.55	3.90	0.2780
S	S	81-59	E	25.50	3.50	23.5	7.73	6.40	4.35	2.05	0.0000
S	S	81-55	E	27.00	-	22.2	7.73	6.25	1.95	4.30	1.1120
S	S	81-51	E	27.50	4.50	21.1	6.76	6.60	3.45	3.15	0.2780
S	S	273	R	17.50	4.00	24.0	8.33	6.95	4.05	2.90	0.2780
S	S	81-03	R	19.75	4.50	24.0	8.69	6.75	4.10	2.65	0.2780
S	S	344	R	19.75	7.50	21.0	6.76	6.95	4.05	2.90	0.2780
S	S	1-269	R	27.75	12.50	24.1	7.73	7.30	3.80	3.50	0.2780
S	S	334	R	32.50	2.00	24.2	8.09	6.95	3.88	3.07	0.1390
S	G	84-32	K	7.00	0.00	20.0	6.67	7.90	3.10	4.80	0.4170
S	G	84-18	K	9.00	0.00	20.0	7.00	7.03	4.03	3.00	0.2780
G	G	185	K	11.50	0.09	20.5	7.00	7.03	3.90	3.13	0.1390
G	G	214	K	10.50	-	20.5	6.67	8.08	3.30	4.78	0.2780
G	G	49	K	9.50	0.00	15.0	-	8.08	3.18	4.90	0.5560
G	G	217	K	11.50	-	27.0	8.33	6.33	2.40	3.93	0.4170
G	G	204	K	14.25	0.09	24.0	8.00	8.08	4.15	3.93	0.4170
G	G	6	K	14.50	-	27.5	9.67	7.20	3.90	3.30	0.2780
G	G	145	K	13.50	0.01	0.3	0.03	7.90	3.63	4.27	0.5560
G	G	201	K	DEAD	-	-	-	DEAD	-	-	-
G	G	184	D	15.50	-	25.5	9.33	7.38	3.90	3.48	0.2780
G	G	104	D	14.25	-	22.0	8.00	7.75	3.25	4.50	0.4170
G	G	39	D	18.50	2.00	23.0	8.33	6.33	3.50	2.83	2.9190
G	G	193	B	18.75	0.03	27.5	6.33	7.55	3.05	4.50	0.4170
G	G	107	D	20.25	2.50	25.0	8.67	6.85	3.35	3.50	0.6950
G	G	110	D	22.00	0.50	24.0	8.67	7.20	3.75	3.45	0.2780
G	G	146	D	17.00	0.50	-	-	7.75	2.85	4.90	0.2780
G	G	140	D	25.00	2.50	24.0	8.33	6.15	3.18	2.97	0.6950
G	G	121	D	27.25	1.00	22.0	0.08	7.03	4.03	3.00	0.1390
G	G	125	D	19.50	2.00	20.0	7.00	8.60	3.10	5.50	0.9730
G	G	84-15	K	8.00	1.00	17.5	6.81	8.78	3.30	5.48	0.8340
G	G	210	K	DEAD	-	-	-	DEAD	-	-	-
G	G	215	K	9.00	-	18.1	5.93	7.90	4.30	3.60	1.5290
G	G	192	K	11.00	6.00	18.0	5.93	7.90	3.75	4.50	1.1120
G	G	216	K	11.00	0.35	22.9	7.70	N.A.	-	-	-
G	G	213	K	11.25	0.00	22.1	8.89	9.13	3.83	5.30	0.6950
G	G	183	K	14.00	1.00	17.5	9.48	8.25	4.10	4.15	0.9730
G	G	194	K	13.00	2.50	25.0	8.89	7.75	4.35	3.40	0.8340
G	G	202	K	14.50	0.50	24.6	8.89	7.03	1.93	5.10	0.9730
G	G	117	K	14.50	1.50	20.0	8.30	7.75	4.15	3.60	0.9730
G	G	111	D	13.50	3.00	23.1	7.41	8.45	3.50	4.95	1.5290
G	G	15	B	15.50	3.00	23.1	7.41	7.55	3.95	3.60	0.4170
G	G	127	D	14.00	3.00	25.6	9.48	7.55	4.10	3.45	1.3900
G	G	122	B	16.50	1.50	27.0	8.89	7.55	2.90	4.65	0.9730
G	G	144	D	17.25	2.00	23.0	8.00	7.38	4.30	3.08	1.1120
G	G	137	D	16.00	1.50	22.0	8.00	7.20	3.83	3.37	1.2510
G	G	105	D	24.00	1.50	24.8	8.30	6.68	4.23	2.45	2.2240
G	G	130	D	18.75	4.50	23.0	8.00	8.78	3.75	5.03	1.2510
G	G	115	D	27.00	4.00	24.6	8.00	6.50	3.70	2.80	2.7800
G	G	101	D	18.25	0.00	24.7	8.00	8.78	3.18	5.60	2.9190
T	G	1	D	WITHDRAWN	-	-	-	-	-	-	-
T	G	2	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	3	D	25.25	0.50	-	-	-	-	-	-
T	G	4	D	24.50	1.50	-	-	-	-	-	-
T	G	5	D	18.50	1.50	-	-	-	-	-	-
T	G	6	D	WITHDRAWN	-	-	-	-	-	-	-
T	G	7	D	20.50	3.00	-	-	-	-	-	-
T	G	8	D	25.75	0.50	-	-	-	-	-	-
T	G	9	B	16.00	0.50	-	-	-	-	-	-
T	G	10	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	11	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	12	K	6.00	6.00	-	-	-	-	-	-
T	G	13	D	WITHDRAWN	-	-	-	-	-	-	-
T	G	14	D	WITHDRAWN	-	-	-	-	-	-	-
T	G	15	B	WITHDRAWN	-	-	-	-	-	-	-
T	G	16	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	17	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	18	D	27.50	2.50	-	-	-	-	-	-
T	G	19	D	25.00	0.50	-	-	-	-	-	-
T	G	20	K	11.50	1.00	-	-	-	-	-	-
T	G	21	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	22	K	16.50	2.00	-	-	-	-	-	-
T	G	24	K	17.75	0.50	-	-	-	-	-	-
T	G	25	K	WITHDRAWN	-	-	-	-	-	-	-
T	G	48	D	23.75	-	-	-	-	-	-	-
T	G	52	K	13.75	0.50	-	-	-	-	-	-

APPENDIX 3

DATA FOR MID-FEBRUARY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	10.70	2.00
S	S	17	L	9.00	2.50
S	S	11	L	9.50	16.00
S	S	16	L	15.80	0.00
S	S	6	L	15.40	1.00
S	S	84-08	E	24.50	0.50
S	S	1-261	E	22.70	0.00
S	S	81-64	E	21.60	10.50
S	S	81-68	E	21.80	1.50
S	S	82-27	E	21.00	10.00
S	S	81-71	E	25.00	0.04
S	S	82-23	E	25.00	2.00
S	S	82-33	E	29.30	2.00
S	S	81-58	E	29.00	1.50
S	S	84-10	E	23.90	2.50
S	S	82-26	E	25.40	2.00
S	S	284	R	23.60	5.00
S	S	329	R	21.70	0.07
S	S	307	R	24.60	2.50
S	S	84-09	R	29.00	1.50
S	S	84-11	R	33.00	2.50
R	S	23	L	10.10	3.00
R	S	7	L	10.30	3.00
R	S	14	L	11.30	0.00
R	S	30	L	12.50	1.00
R	S	22	L	15.00	2.00
R	S	1-266	E	21.70	1.00
R	S	82-34	E	22.00	7.50
R	S	82-14	E	26.50	7.50
R	S	81-54	E	26.60	10.50
R	S	81-52	E	24.00	0.09
R	S	81-72	E	23.00	2.00
R	S	81-73	E	27.60	2.00
R	S	1-267	E	26.20	0.01
R	S	81-59	E	26.70	3.00
R	S	81-55	E	29.70	0.50
R	S	81-51	E	27.50	2.00
R	S	273	R	18.30	0.50
R	S	81-03	R	19.50	11.50
R	S	344	R	21.00	2.00
R	S	1-269	R	27.50	1.00
R	S	334	R	32.50	4.00
T	S	230N	E	25.50	0.00
T	S	233N	E	21.50	-
T	S	234N	E	16.00	8.50
T	S	237N	E	18.50	4.00
T	S	39N	L	14.00	2.00
T	S	45N	E	23.75	0.08
T	S	46N	E	24.50	8.00
T	S	229N	E	29.50	0.50
T	S	53N	E	19.50	5.50
T	S	226N	L	16.00	0.50
T	S	231N	R	19.00	-
T	S	235N	L	9.50	18.00
S	G	84-32	K	7.50	0.00
S	G	84-18	K	9.50	0.00
S	G	185	K	9.00	0.00
S	G	214	K	9.00	0.01
S	G	49	K	10.00	0.00
S	G	217	K	10.00	1.00
S	G	204	K	13.50	0.03
S	G	6	K	14.00	0.50
S	G	145	K	13.75	0.00
S	G	201	K	-	-
S	G	184	D	15.00	0.00
S	G	104	D	14.00	0.00
S	G	39	D	17.50	0.01
S	G	193	B	18.75	0.00
S	G	107	D	19.75	0.50
S	G	110	D	21.50	0.04
S	G	146	D	16.25	5.50
S	G	140	D	26.50	0.01
S	G	121	D	26.00	1.00
S	G	125	D	19.50	0.00
R	G	84-15	K	8.50	5.50
R	G	210	K	-	-
R	G	215	K	9.00	0.00
R	G	192	K	10.50	0.08
R	G	216	K	11.00	1.50
R	G	213	K	10.50	0.05
R	G	183	K	14.25	2.50
R	G	194	K	13.25	5.50
R	G	202	K	14.50	0.01
R	G	117	K	14.50	0.50
R	G	111	D	13.25	0.00
R	G	15	B	16.00	0.01
R	G	127	D	14.25	1.00
R	G	122	B	17.00	4.50
R	G	144	D	17.75	0.50
R	G	137	D	17.00	1.00
R	G	105	D	24.50	0.50
R	G	130	D	18.50	1.00
R	G	115	D	25.00	5.50
R	G	101	D	18.00	0.00

APPENDIX 3

DATA FOR THE END OF FEBRUARY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	PLASMA PEPSINOGE (i.u.)
S	S	25	L	10.50	-	26.2	8.30	-	-	6.33	3.40	2.93	-
S	S	17	L	7.50	-	18.5	4.74	-	-	6.50	2.45	4.05	-
S	S	11	L	9.50	-	21.0	4.74	-	-	7.38	2.85	4.53	-
S	S	16	L	15.80	-	19.0	5.93	-	-	N.A.	-	-	-
S	S	6	L	15.25	-	29.0	8.89	-	-	6.85	4.30	2.55	-
S	S	84-08	E	23.00	-	25.5	8.89	-	-	6.33	3.95	2.38	-
S	S	1-261	E	22.75	-	21.5	5.93	-	-	6.33	3.65	2.68	-
S	S	81-64	E	20.75	-	16.0	4.74	-	-	6.68	2.93	3.75	-
S	S	81-68	E	19.00	-	23.7	7.11	-	-	6.85	3.15	3.70	-
S	S	82-27	E	19.50	-	23.2	6.22	-	-	6.15	4.75	1.40	-
S	S	81-71	E	23.25	-	23.7	8.00	-	-	6.33	2.85	3.48	-
S	S	82-23	E	23.50	-	29.0	8.59	-	-	7.03	3.30	3.73	-
S	S	82-33	E	23.50	-	26.2	8.89	-	-	5.98	3.45	2.53	-
S	S	81-58	E	22.25	-	22.0	7.11	-	-	7.38	2.93	4.45	-
S	S	84-10	E	19.00	-	17.5	5.93	-	-	6.15	2.75	3.40	-
S	S	82-26	E	25.50	-	23.7	8.00	-	-	6.68	4.43	2.25	-
S	S	284	R	21.50	-	24.5	8.00	-	-	6.50	3.10	3.40	-
S	S	329	R	21.25	-	23.0	7.11	-	-	6.68	3.10	3.58	-
S	S	307	R	22.75	-	25.0	8.30	-	-	7.38	-	-	-
S	S	84-09	R	27.00	-	30.5	8.59	-	-	7.20	3.45	3.75	-
S	S	84-11	R	32.25	-	31.5	8.59	-	-	7.20	3.80	3.40	-
R	S	23	L	9.50	-	26.2	7.70	-	-	7.75	2.60	5.15	0.626
R	S	7	L	9.75	-	21.5	6.22	-	-	6.68	3.00	3.68	0.000
R	S	14	L	11.00	-	29.5	8.30	-	-	6.50	2.60	3.90	0.000
R	S	30	L	12.50	-	31.5	8.30	-	-	7.20	1.65	5.55	0.000
R	S	22	L	14.75	-	30.0	7.70	-	-	6.68	2.45	4.23	0.104
R	S	1-266	E	21.75	-	26.0	7.70	-	-	7.20	3.10	4.10	0.000
R	S	82-34	E	20.25	-	21.0	7.11	-	-	7.38	3.15	4.23	0.174
R	S	82-14	E	26.00	-	24.0	6.52	-	-	7.20	2.10	5.10	0.834
R	S	81-54	E	20.25	-	21.5	6.22	-	-	6.50	2.35	4.15	0.765
R	S	81-52	E	21.75	-	23.7	7.11	-	-	N.A.	-	-	-
R	S	81-72	E	21.50	-	22.0	6.22	-	-	7.03	2.10	4.93	0.417
R	S	81-73	E	28.00	-	19.2	6.22	-	-	7.20	2.60	4.60	0.000
R	S	1-267	E	23.75	-	29.2	9.19	-	-	7.20	2.93	4.27	1.043
R	S	81-59	E	26.00	-	26.5	7.70	-	-	7.03	2.93	4.10	0.487
R	S	81-55	E	28.00	-	26.0	7.11	-	-	6.50	2.45	4.05	0.278
R	S	81-51	E	28.75	-	19.5	5.33	-	-	7.03	3.25	2.78	0.000
R	S	273	R	18.00	-	25.0	8.30	-	-	7.20	2.45	4.75	0.765
R	S	81-03	R	18.75	-	25.0	-	-	-	7.55	2.45	5.10	0.000
R	S	344	R	18.75	-	24.0	8.30	-	-	7.20	2.45	4.75	0.000
R	S	1-269	R	26.75	-	-	-	-	-	7.90	2.45	5.45	0.348
R	S	334	R	32.50	-	25.7	7.70	-	-	7.20	2.60	4.60	0.104
T	S	230N	E	25.00	5.50	25.5	8.62	9.35	17.60	7.45	3.15	4.30	1.390
T	S	233N	E	21.50	5.50	21.0	7.08	6.98	17.20	6.60	3.25	3.35	0.139
T	S	234N	E	17.75	9.50	26.0	8.31	9.90	23.05	6.75	2.28	4.47	0.834
T	S	237N	E	17.75	5.00	26.2	8.62	7.02	13.65	7.65	2.60	5.05	0.000
T	S	39N	L	14.00	0.00	28.5	3.69	8.08	9.60	7.45	4.05	3.40	1.390
T	S	45N	E	24.25	1.00	20.0	6.15	6.72	12.10	7.10	3.80	3.30	0.000
T	S	46N	E	26.25	5.50	20.0	6.15	6.72	12.10	6.95	2.85	4.10	0.695
T	S	229N	E	29.50	0.00	29.0	10.77	9.05	10.25	7.45	3.70	3.75	0.556
T	S	53N	E	21.75	14.50	22.0	7.38	7.63	10.35	8.35	2.93	5.42	2.780
T	S	226N	L	16.50	3.00	28.7	9.54	10.86	10.95	7.80	4.05	3.75	1.112
T	S	231N	R	19.00	24.50	26.0	8.31	8.99	8.85	9.20	3.80	5.40	0.278
T	S	235N	L	10.50	18.00	19.5	5.85	5.03	8.90	6.60	2.93	3.67	0.417
S	G	84-32	K	6.95	-	24.5	7.08	-	-	7.75	2.00	5.75	0.417
S	G	84-18	K	9.50	-	24.0	6.77	-	-	7.38	3.18	4.20	0.348
S	G	185	K	9.00	-	18.0	5.85	-	-	7.55	2.25	5.30	0.104
S	G	214	K	9.00	-	15.2	3.69	-	-	7.38	2.20	5.18	0.904
S	G	49	K	9.50	-	19.5	5.54	-	-	8.08	2.40	5.68	0.417
S	G	217	K	9.50	-	16.5	4.00	-	-	8.60	1.35	7.25	0.765
S	G	204	K	13.25	-	22.2	6.77	-	-	7.55	2.25	5.30	1.251
S	G	6	K	14.00	-	32.0	8.92	-	-	7.90	2.65	5.25	1.321
S	G	145	K	13.50	-	22.5	6.77	-	-	7.90	3.30	4.60	0.056
S	G	184	D	15.50	-	28.0	8.62	-	-	DEAD	-	-	-
S	G	104	D	13.75	-	21.0	5.85	-	-	N.A.	-	-	-
S	G	39	D	15.75	-	22.5	6.77	-	-	7.75	1.85	5.90	0.487
S	G	193	B	18.50	-	29.0	9.54	-	-	6.68	2.13	4.55	0.834
S	G	107	D	17.00	-	22.7	6.77	-	-	6.85	2.13	4.72	0.765
S	G	110	D	19.00	-	27.5	8.00	-	-	6.33	2.05	4.28	0.695
S	G	146	D	16.00	-	23.0	6.46	-	-	7.38	2.40	4.98	0.278
S	G	140	D	21.60	-	24.5	7.08	-	-	N.A.	-	-	-
S	G	121	D	20.40	-	24.0	4.92	-	-	7.20	2.73	4.47	0.056
S	G	125	D	18.25	-	19.0	9.54	-	-	7.20	1.85	5.35	0.348
R	G	84-15	K	8.00	-	17.5	4.62	-	-	8.78	2.53	6.25	0.278
R	G	215	K	9.00	-	15.5	4.31	-	-	8.15	2.13	6.02	1.251
R	G	192	K	10.75	-	15.0	4.62	-	-	DEAD	-	-	-
R	G	216	K	10.50	-	19.0	5.85	-	-	8.50	3.25	5.25	0.973
R	G	213	K	10.75	-	18.5	5.85	-	-	7.65	3.45	4.20	2.224
R	G	183	K	14.50	-	26.7	7.69	-	-	8.50	2.65	5.85	1.251
R	G	194	K	13.00	-	23.5	5.23	-	-	N.A.	2.40	N.A.	0.487
R	G	202	K	13.75	-	21.0	6.15	-	-	8.70	3.25	5.45	1.599
R	G	117	K	14.75	-	23.7	6.77	-	-	7.10	3.25	3.85	2.224
R	G	111	D	13.00	-	20.5	5.85	-	-	7.10	2.65	4.45	1.390
R	G	15	B	15.50	-	20.2	5.85	-	-	8.00	3.25	4.75	2.502
R	G	127	D	14.40	-	26.0	8.62	-	-	8.00	2.73	5.27	1.529
R	G	122	B	16.95	-	27.0	8.00	-	-	7.45	2.85	4.60	0.626
R	G	144	D	17.25	-	26.0	8.62	-	-	7.10	2.98	4.12	0.973
R	G	137	D	17.50	-	22.5	6.77	-	-	7.45	2.98	4.47	1.599
R	G	105	D	19.50	-	23.5	7.08	-	-	7.30	3.18	4.12	1.182
R	G	130	D	19.00	-	22.0	6.77	-	-	7.30	2.58	4.72	2.224
R	G	115	D	24.60	-	21.0	5.85	-	-	7.30	3.25	4.05	1.946
R	G	101	D	18.50	-	24.5	7.38	-	-	8.85	N.A.	N.A.	1.251
T	G	3	D	23.50	-	20.7	6.46	9.43	16.85	6.60	2.73	3.87	2.224
T	G	4	D	23.50	4.00	27.2	8.00	11.60	15.95	8.00	2.20	5.80	0.973
T	G	5	D	22.50	0.50	27.2	7.38	11.07	18.15	6.95	2.30	4.65	1.529
T	G	7	D	23.00	4.50	23.7	7.38	10.24	20.65	9.40	3.75	5.65	0.973
T	G	8	D	23.00	2.50	23.7	7.38	11.14	17.85	6.95	3.45	3.50	1.251
T	G	9	B	19.00	2.00	24.7	8.00	9.93	19.00	8.15	3.63	4.52	1.043
T	G	12	K	8.50	1.50	20.0	6.15	4.88	19.90	8.00	3.10	4.90	N.A.
T	G	15	D	20.50	1.50	21.0	7.08	9.20	15.25	8.35	3.45	4.90	N.A.
T	G	16	D	15.25	2.00	24.2	8.00	10.84	11.15	8.15	3.05	5.10	1.112
T	G	18	D	27.50	2.00	19.0	6.15	6.39	21.20	8.50	3.18	5.32	2.502
T	G	19	D	26.50	2.00	18.5	6.77	7.79	9.75	8.70	3.50	5.20	0.348
T	G	22	K	19.25	1.50	25.5	7.69	8.96	8.70	8.50	2.98	5.52	0.765
T	G	23	D	20.50	1.00	27.0	8.62	11.67	11.30	8.00	3.05	4.95	1.529
T	G	24	K	20.50	3.00	29.0	8.62	13.88	17.40	N.A.	-	-	-
T	G	25	K	9.50	3.50	23.7	7.38	11.40	14.10	7.45	3.10	4.35	0.556
T	G	42	K	10.25	4.50	22.2	6.46	11.35	19.50	7.30	3.25	4.05	1.877
T	G	48	D	24.25	4.00	22.5	7.08	9.43	12.35	6.75	3.55	3.20	0.104

APPENDIX 3

DATA FOR MID-MARCH 1985

GROUP	TYPE	NUMBER	AGE - SEX	FAECAL EPG (x100)
S	S	25	L	3.50
S	S	17	L	3.50
S	S	11	L	2.50
S	S	16	L	0.50
S	S	6	L	4.00
S	S	84-08	E	0.50
S	S	1-261	E	1.50
S	S	81-64	E	22.50
S	S	81-68	E	10.50
S	S	82-27	E	10.50
S	S	81-71	E	1.00
S	S	82-23	E	6.00
S	S	82-33	E	1.00
S	S	81-58	E	11.50
S	S	84-10	E	8.50
S	S	82-26	E	-
S	S	284	R	4.00
S	S	329	R	2.50
S	S	307	R	3.00
S	S	84-09	R	0.50
S	S	84-11	R	1.00
R	S	23	L	0.03
R	S	7	L	0.50
R	S	14	L	0.50
R	S	30	L	2.50
R	S	22	L	1.00
R	S	1-266	E	0.50
R	S	82-34	E	2.50
R	S	82-14	E	3.00
R	S	81-54	E	9.00
R	S	81-52	E	1.00
R	S	81-72	E	2.00
R	S	81-73	E	3.00
R	S	1-267	E	0.00
R	S	81-59	E	1.00
R	S	81-55	E	0.50
R	S	81-51	E	0.00
R	S	273	R	11.00
R	S	81-03	R	7.50
R	S	344	R	0.00
R	S	1-269	R	-
R	S	334	R	0.00
S	G	84-32	K	0.00
S	G	84-18	K	0.00
S	G	185	K	0.00
S	G	214	K	0.00
S	G	49	K	0.00
S	G	217	K	0.00
S	G	204	K	0.00
S	G	6	K	0.04
S	G	145	K	0.00
S	G	184	D	0.00
S	G	104	D	0.50
S	G	39	D	0.50
S	G	193	B	0.00
S	G	107	D	0.50
S	G	110	D	0.01
S	G	146	D	0.00
S	G	140	D	0.50
S	G	121	D	1.50
S	G	125	D	0.00
R	G	84-15	K	1.50
R	G	215	K	1.50
R	G	192	K	1.00
R	G	216	K	0.11
R	G	213	K	0.11
R	G	183	K	0.50
R	G	194	K	0.00
R	G	202	K	0.50
R	G	117	K	0.16
R	G	111	D	-
R	G	15	B	0.50
R	G	127	D	0.08
R	G	122	B	0.00
R	G	144	D	0.05
R	G	137	D	0.50
R	G	105	D	0.15
R	G	130	D	0.13
R	G	115	D	0.05
R	G	101	D	0.03

APPENDIX 3

DATA FOR THE END OF MARCH 1985

GROUP	TYPE	NUMBER	AGE - SEX	FAECAL EPG (x100)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl
S	S	25	L	1.00	6.40	3.88	2.52
S	S	17	L	-	7.20	2.60	4.60
S	S	11	L	1.50	6.25	3.40	2.85
S	S	16	L	0.50	6.10	3.10	3.00
S	S	6	L	5.50	6.65	3.88	2.77
S	S	84-08	E	1.00	7.90	3.30	4.60
S	S	1-261	E	0.01	10.34	5.26	3.30
S	S	81-64	E	43.00	7.20	2.60	4.60
S	S	81-68	E	8.50	6.93	3.30	3.63
S	S	82-27	E	14.00	7.48	3.10	4.38
S	S	81-71	E	0.00	6.93	2.93	4.00
S	S	82-23	E	7.00	6.65	3.40	3.25
S	S	82-33	E	0.50	6.10	3.45	2.65
S	S	81-58	E	7.50	7.20	3.00	4.20
S	S	84-10	E	0.50	5.83	3.25	2.58
S	S	82-26	E	0.11	6.53	3.65	2.88
S	S	284	R	2.00	6.10	3.30	2.80
S	S	329	R	0.50	6.93	3.88	3.05
S	S	307	R	1.50	6.65	3.65	3.00
S	S	84-09	R	2.00	7.48	4.50	2.98
S	S	84-11	R	0.50	5.28	4.20	1.08
R	S	23	L	1.00	6.80	3.70	3.10
R	S	7	L	0.50	5.28	3.95	1.33
R	S	14	L	0.50	6.93	3.95	2.98
R	S	30	L	1.00	5.28	3.45	1.83
R	S	22	L	0.50	7.20	3.95	3.25
R	S	1-266	E	0.01	6.93	3.00	3.93
R	S	82-34	E	0.50	6.80	3.45	3.35
R	S	82-14	E	2.50	5.55	3.15	2.40
R	S	81-54	E	5.50	6.65	3.30	3.35
R	S	81-52	E	1.00	6.65	3.65	3.00
R	S	81-72	E	1.50	6.40	2.70	3.70
R	S	81-73	E	3.00	5.95	3.25	2.70
R	S	1-267	E	0.00	5.95	3.40	3.55
R	S	81-59	E	1.00	6.65	3.95	2.70
R	S	81-55	E	1.00	5.95	3.30	2.65
R	S	81-51	E	0.00	5.13	3.15	1.98
R	S	273	R	1.00	4.15	3.30	0.85
R	S	81-03	R	1.50	6.93	3.65	3.28
R	S	344	R	0.01	6.93	3.00	3.93
R	S	1-269	R	-	7.63	3.80	3.83
R	S	334	R	0.00	6.65	3.80	2.85
T	S	230N	E	2.50	-	-	-
T	S	233N	E	1.00	-	-	-
T	S	234N	E	8.00	-	-	-
T	S	237N	E	3.50	-	-	-
T	S	39N	L	0.50	-	-	-
T	S	45N	E	0.50	-	-	-
T	S	46N	E	8.50	-	-	-
T	S	229N	E	0.50	-	-	-
T	S	53N	E	5.50	-	-	-
T	S	226N	L	0.03	-	-	-
T	S	231N	R	10.00	-	-	-
T	S	235N	L	15.00	-	-	-
S	G	84-32	K	1.50	9.30	3.45	5.85
S	G	84-18	K	0.01	8.60	3.75	4.85
S	G	185	K	0.01	7.55	2.98	4.57
S	G	214	K	0.00	7.63	1.60	6.03
S	G	49	K	0.50	8.13	3.18	4.95
S	G	217	K	0.05	11.70	2.30	9.40
S	G	204	K	0.04	7.30	2.25	5.05
S	G	6	K	0.00	8.18	3.05	5.13
S	G	145	K	0.00	8.60	3.50	5.10
S	G	201	K	DEAD	-	-	-
S	G	184	D	0.04	6.65	3.70	2.95
S	G	104	D	0.00	7.25	2.85	4.40
S	G	39	D	0.50	7.48	2.65	4.83
S	G	193	B	0.03	7.05	2.98	4.07
S	G	107	D	1.00	6.53	3.18	3.35
S	G	110	D	0.50	7.20	3.45	3.75
S	G	146	D	1.00	8.33	2.40	5.93
S	G	140	D	0.20	8.05	3.45	4.60
S	G	121	D	1.00	9.00	3.25	5.75
S	G	125	D	0.03	7.35	2.98	4.37
R	G	84-15	K	0.50	6.65	3.05	3.60
R	G	210	K	DEAD	-	-	-
R	G	215	K	0.50	9.30	3.18	6.12
R	G	192	K	1.50	8.33	3.30	5.03
R	G	216	K	0.01	9.00	3.05	5.95
R	G	213	K	0.50	7.35	3.25	4.10
R	G	183	K	0.50	8.33	3.18	5.15
R	G	194	K	0.00	8.05	3.10	4.95
R	G	202	K	0.50	6.40	2.58	3.82
R	G	117	K	0.50	7.63	3.30	4.33
R	G	111	D	1.50	9.00	2.65	6.35
R	G	15	B	0.21	8.18	3.75	4.43
R	G	127	D	4.50	7.35	3.18	4.17
R	G	122	B	0.00	6.53	2.58	3.95
R	G	144	D	2.00	8.33	2.90	5.43
R	G	137	D	0.50	6.93	3.18	3.75
R	G	105	D	1.50	6.25	3.18	3.07
R	G	130	D	1.00	N.A.	2.90	N.A.
R	G	115	D	0.03	7.75	3.18	4.57
R	G	101	D	0.50	8.05	3.45	4.60
T	G	3	D	0.50	-	-	-
T	G	4	D	0.32	-	-	-
T	G	5	D	1.00	-	-	-
T	G	7	D	9.00	-	-	-
T	G	8	D	1.00	-	-	-
T	G	9	B	0.50	-	-	-
T	G	12	K	0.01	-	-	-
T	G	15	D	0.01	-	-	-
T	G	16	D	1.50	-	-	-
T	G	18	D	0.50	-	-	-
T	G	19	D	1.00	-	-	-
T	G	20	K	2.00	-	-	-
T	G	22	K	0.50	-	-	-
T	G	23	D	3.00	-	-	-
T	G	24	K	1.00	-	-	-
T	G	25	K	0.05	-	-	-
T	G	42	K	0.50	-	-	-
T	G	48	D	2.00	-	-	-

APPENDIX 3

DATA FOR MID-APRIL 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	11.75	0.00
S	S	17	L	7.00	DEAD
S	S	11	L	10.25	0.01
S	S	16	L	15.50	2.00
S	S	6	L	17.25	1.50
S	S	84-08	E	18.00	1.00
S	S	1-261	E	19.00	3.00
S	S	81-64	E	23.25	DEAD
S	S	81-68	E	19.50	3.50
S	S	82-27	E	19.75	5.50
S	S	81-71	E	24.75	0.00
S	S	82-23	E	19.75	0.50
S	S	82-33	E	22.50	0.50
S	S	81-58	E	19.25	3.50
S	S	84-10	E	19.00	1.50
S	S	82-26	E	22.00	0.50
S	S	284	R	23.25	3.00
S	S	329	R	22.50	2.00
S	S	307	R	24.75	0.50
S	S	84-09	R	27.25	4.00
S	S	84-11	R	32.50	0.03
R	S	23	L	14.00	17.50
R	S	7	L	12.25	13.00
R	S	14	L	13.50	5.00
R	S	30	L	14.25	1.00
R	S	22	L	17.50	3.50
R	S	1-266	E	19.50	0.50
R	S	82-34	E	20.25	0.12
R	S	82-14	E	22.25	9.50
R	S	81-54	E	19.25	27.00
R	S	81-52	E	21.50	10.00
R	S	81-72	E	21.75	4.50
R	S	81-73	E	26.25	28.50
R	S	1-267	E	29.25	0.00
R	S	81-59	E	22.00	56.50
R	S	81-55	E	24.25	2.00
R	S	81-51	E	25.75	0.00
R	S	273	R	21.25	7.50
R	S	81-03	R	19.25	8.50
R	S	344	R	21.75	1.50
R	S	1-269	R	27.25	5.00
R	S	334	R	34.25	0.00
S	G	84-32	K	7.25	0.50
S	G	84-18	K	11.00	0.50
S	G	185	K	9.00	1.00
S	G	214	K	DEAD	-
S	G	49	K	10.50	0.03
S	G	217	K	11.00	0.50
S	G	204	K	14.00	0.07
S	G	6	K	17.00	0.00
S	G	145	K	13.50	0.00
S	G	184	D	16.25	0.50
S	G	104	D	15.00	0.00
S	G	39	D	17.50	0.04
S	G	193	B	19.25	0.07
S	G	107	D	18.00	1.00
S	G	110	D	19.00	0.05
S	G	146	D	16.50	0.04
S	G	140	D	22.25	0.50
S	G	121	D	20.00	0.37
S	G	125	D	20.00	1.00
R	G	84-15	K	9.00	7.50
R	G	215	K	9.50	18.00
R	G	192	K	11.75	5.00
R	G	216	K	12.00	3.00
R	G	213	K	DEAD	-
R	G	183	K	15.50	1.00
R	G	194	K	12.50	3.50
R	G	202	K	14.50	1.00
R	G	117	K	15.00	-
R	G	111	D	14.00	8.50
R	G	15	B	16.25	4.00
R	G	127	D	-	2.00
R	G	122	B	18.50	0.50
R	G	144	D	-	9.50
R	G	137	D	13.70	4.00
R	G	105	D	19.75	1.00
R	G	130	D	20.00	7.00
R	G	115	D	19.75	7.50
R	G	101	D	20.50	4.00

APPENDIX 3

DATA FOR THE END OF APRIL 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%
S	S	25	L	12.75	0.00	26.0	9.20
S	S	17	L	DEAD	-	-	-
S	S	11	L	11.50	0.50	24.0	6.94
S	S	16	L	16.00	0.50	21.5	7.08
S	S	6	L	19.00	1.50	25.7	8.35
S	S	84-08	E	21.00	3.50	20.5	6.65
S	S	1-261	E	19.00	3.00	19.5	6.23
S	S	81-64	E	DEAD	-	-	-
S	S	81-68	E	21.50	1.50	31.0	9.63
S	S	82-27	E	22.25	2.00	24.5	7.79
S	S	81-71	E	27.00	0.00	22.0	6.65
S	S	82-23	E	21.00	4.50	23.0	6.94
S	S	82-33	E	22.75	1.50	21.2	7.22
S	S	81-58	E	22.00	0.50	19.0	6.09
S	S	84-10	E	19.00	3.50	22.2	7.08
S	S	82-26	E	23.50	0.01	23.2	7.79
S	S	284	R	24.25	5.50	19.0	5.66
S	S	329	R	24.50	0.50	23.7	7.36
S	S	307	R	27.00	4.00	23.5	7.79
S	S	84-09	R	28.00	1.00	27.0	9.35
S	S	84-11	R	33.50	2.00	29.7	9.63
R	S	23	L	15.50	5.00	26.5	8.78
R	S	7	L	13.50	4.00	27.0	9.06
R	S	14	L	15.00	0.03	27.0	9.20
R	S	30	L	15.00	0.50	28.7	9.20
R	S	22	L	18.00	2.00	30.7	9.20
R	S	1-266	E	20.75	0.00	27.2	8.64
R	S	82-34	E	21.25	0.50	21.5	7.22
R	S	82-14	E	22.25	2.50	20.0	6.09
R	S	81-54	E	21.25	2.50	20.0	6.09
R	S	81-52	E	21.75	1.00	18.5	5.52
R	S	81-72	E	22.50	1.00	23.5	7.65
R	S	81-73	E	26.25	3.50	21.0	5.95
R	S	1-267	E	30.75	0.00	26.5	9.06
R	S	81-59	E	22.75	5.50	16.2	4.81
R	S	81-55	E	26.00	1.00	26.0	7.65
R	S	81-51	E	25.50	0.00	19.2	6.37
R	S	273	R	23.50	1.50	29.0	9.91
R	S	81-03	R	22.25	0.50	26.0	8.35
R	S	344	R	23.00	1.00	25.0	8.21
R	S	1-269	R	30.00	0.13	27.0	9.20
R	S	334	R	37.50	0.00	31.7	9.77
T	S	230N	E	20.50	0.50	-	-
T	S	233N	E	18.25	4.50	-	-
T	S	234N	E	18.75	14.50	-	-
T	S	237N	E	18.50	3.00	-	-
T	S	39N	L	16.25	0.03	-	-
T	S	45N	E	25.00	0.12	-	-
T	S	46N	E	28.00	7.00	-	-
T	S	229N	E	31.00	2.00	-	-
T	S	53N	E	22.75	10.00	-	-
T	S	226N	L	18.25	0.08	-	-
T	S	231N	R	20.00	7.00	-	-
T	S	235N	L	11.25	19.00	-	-
S	G	84-32	K	8.50	0.50	28.5	10.33
S	G	84-18	K	10.25	0.09	26.5	9.31
S	G	185	K	8.50	0.50	21.7	7.11
S	G	214	K	DEAD	-	-	-
S	G	49	K	11.25	0.50	27.0	9.31
S	G	217	K	12.25	2.50	30.5	7.27
S	G	204	K	14.75	1.50	25.0	8.44
S	G	6	K	17.50	1.00	33.2	10.67
S	G	145	K	14.00	0.50	30.0	9.45
S	G	184	D	17.25	1.00	32.0	10.76
S	G	104	D	15.50	0.04	32.0	10.76
S	G	39	D	17.50	2.00	30.5	10.62
S	G	193	B	20.00	0.50	32.0	10.33
S	G	107	D	17.25	4.50	23.5	8.29
S	G	110	D	19.25	0.50	28.0	9.60
S	G	146	D	17.00	2.00	25.5	8.44
S	G	140	D	24.00	0.23	31.0	10.04
S	G	121	D	22.00	0.50	26.0	8.87
S	G	125	D	21.00	1.00	30.0	10.04
R	G	84-15	K	9.50	3.50	27.0	8.58
R	G	215	K	9.50	4.00	17.5	7.71
R	G	192	K	11.50	2.50	29.0	9.89
R	G	216	K	12.00	1.50	17.0	9.02
R	G	213	K	DEAD	-	-	-
R	G	183	K	15.00	0.03	26.0	8.58
R	G	194	K	12.50	0.50	30.0	9.60
R	G	202	K	13.75	3.00	19.5	9.75
R	G	117	K	15.00	0.50	27.5	8.73
R	G	111	D	14.25	3.00	25.0	8.58
R	G	15	B	16.50	0.50	25.0	8.29
R	G	127	D	-	2.50	27.2	9.75
R	G	122	B	17.75	0.01	31.0	9.31
R	G	144	D	-	1.00	26.5	8.87
R	G	137	D	20.25	1.00	25.0	9.31
R	G	105	D	20.50	1.50	25.0	8.00
R	G	130	D	22.50	2.00	29.0	9.93
R	G	115	D	20.50	8.50	17.0	5.67
R	G	101	D	21.00	0.00	27.0	7.56
T	G	3	D	22.50	-	-	-
T	G	4	D	21.00	0.20	-	-
T	G	5	D	16.25	0.50	-	-
T	G	7	D	19.00	2.00	-	-
T	G	8	D	19.50	0.20	-	-
T	G	9	B	15.00	0.03	-	-
T	G	12	K	8.75	0.50	-	-
T	G	15	D	18.50	1.50	-	-
T	G	16	D	16.25	1.50	-	-
T	G	18	D	27.00	1.50	-	-
T	G	19	D	24.00	1.00	-	-
T	G	20	K	12.75	0.50	-	-
T	G	22	K	18.75	6.00	-	-
T	G	23	D	22.00	6.50	-	-
T	G	24	K	19.50	10.00	-	-
T	G	25	K	10.25	4.50	-	-
T	G	42	K	12.00	0.50	-	-
T	G	48	D	23.00	2.00	-	-

APPENDIX 3

DATA FOR MID-MAY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	14.50	0.01
S	S	17	L	DEAD	-
S	S	11	L	13.00	7.00
S	S	16	L	16.50	2.00
S	S	6	L	19.50	15.00
S	S	84-08	E	22.00	15.00
S	S	1-261	E	21.00	0.32
S	S	81-64	E	DEAD	-
S	S	81-68	E	23.50	1.50
S	S	82-27	E	0.00	-
S	S	81-71	E	30.25	0.00
S	S	82-23	E	23.00	7.50
S	S	82-33	E	23.00	0.00
S	S	81-58	E	22.50	0.50
S	S	84-10	E	21.25	7.00
S	S	82-26	E	24.00	0.01
S	S	284	R	25.50	4.50
S	S	329	R	26.00	1.00
S	S	307	R	29.00	2.00
S	S	84-09	R	29.00	5.00
S	S	84-11	R	35.50	3.00
R	S	23	L	16.25	11.50
R	S	7	L	14.50	3.50
R	S	14	L	15.50	6.00
R	S	30	L	15.50	6.50
R	S	22	L	17.75	0.50
R	S	1-266	E	22.75	0.00
R	S	82-34	E	22.50	0.50
R	S	82-14	E	21.50	20.00
R	S	81-54	E	22.50	1.00
R	S	81-52	E	21.75	5.00
R	S	81-72	E	23.00	19.50
R	S	81-73	E	25.75	11.50
R	S	1-267	E	29.50	0.00
R	S	81-59	E	19.75	49.50
R	S	81-55	E	24.00	2.00
R	S	81-51	E	27.00	0.00
R	S	273	R	24.50	9.50
R	S	81-03	R	23.00	8.00
R	S	344	R	24.00	2.00
R	S	1-269	R	32.25	1.50
R	S	334	R	39.00	0.50
S	G	84-32	K	9.00	0.05
S	G	84-18	K	10.50	2.50
S	G	185	K	8.75	3.00
S	G	214	K	DEAD	-
S	G	49	K	12.00	3.50
S	G	217	K	12.50	1.50
S	G	204	K	15.00	3.00
S	G	6	K	18.00	2.50
S	G	145	K	13.50	0.00
S	G	184	D	17.50	0.50
S	G	104	D	14.50	0.01
S	G	39	D	18.00	5.50
S	G	193	B	20.25	1.00
S	G	107	D	17.25	6.00
S	G	110	D	19.00	3.00
S	G	146	D	16.75	0.00
S	G	140	D	24.75	1.00
S	G	121	D	22.50	1.00
S	G	125	D	21.75	1.00
R	G	84-15	K	10.00	1.50
R	G	215	K	9.75	15.00
R	G	192	K	12.25	8.00
R	G	216	K	12.25	2.00
R	G	213	K	DEAD	-
R	G	183	K	16.50	1.00
R	G	194	K	12.50	2.00
R	G	202	K	14.25	4.50
R	G	117	K	15.50	2.50
R	G	111	D	14.75	7.00
R	G	15	B	17.00	6.00
R	G	127	D	17.50	6.00
R	G	122	B	18.50	2.50
R	G	144	D	18.75	7.00
R	G	137	D	21.00	4.50
R	G	105	D	20.25	1.50
R	G	130	D	23.50	5.50
R	G	115	D	21.00	8.50
R	G	101	D	22.00	0.50

APPENDIX 3

DATA FOR THE END OF MAY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	SERUM PEPSINOGEN (i.u.)
S	S	25	L	14.25	0.00	26.2	9.86	-	-	6.85	4.30	2.55	-
S	S	17	L	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	11	L	13.00	1.00	24.2	8.86	-	-	7.30	3.88	3.42	-
S	S	16	L	16.50	1.50	22.5	7.57	-	-	5.90	2.50	3.40	-
S	S	6	L	19.20	3.00	25.0	10.86	-	-	6.75	3.88	2.87	-
S	S	84-08	E	21.75	1.00	23.0	8.71	-	-	7.58	3.65	3.93	-
S	S	1-261	E	21.00	2.50	17.0	6.29	-	-	7.30	2.75	4.55	-
S	S	81-64	E	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	81-68	E	23.25	0.00	28.0	9.71	-	-	7.70	3.30	4.40	-
S	S	82-27	E	23.50	0.05	22.7	8.14	-	-	6.75	2.93	3.82	-
S	S	81-71	E	29.50	0.50	23.7	9.14	-	-	8.80	3.95	4.85	-
S	S	82-23	E	22.75	4.50	24.5	8.29	-	-	7.00	3.00	4.00	-
S	S	82-33	E	24.00	0.50	23.0	8.43	-	-	7.15	3.95	3.20	-
S	S	81-58	E	22.00	0.00	18.0	6.14	-	-	8.13	3.00	5.13	-
S	S	84-10	E	21.50	1.00	23.2	8.29	-	-	7.85	3.40	4.45	-
S	S	82-26	E	24.70	0.00	25.0	9.14	-	-	6.85	4.30	2.55	-
S	S	284	R	26.00	8.00	21.2	7.14	-	-	6.75	3.55	3.20	-
S	S	329	R	26.50	0.50	27.5	9.29	-	-	7.85	3.95	3.90	-
S	S	307	R	29.00	3.00	23.2	8.57	-	-	7.15	4.05	3.10	-
S	S	84-09	R	29.00	2.50	27.0	9.86	-	-	7.58	4.10	3.48	-
S	S	84-11	R	36.00	N.A.	26.0	9.14	-	-	7.40	3.45	3.95	-
R	S	23	L	17.00	6.00	24.0	6.37	-	-	7.08	3.80	3.28	-
R	S	7	L	14.70	4.50	25.5	15.26	-	-	6.80	4.10	2.70	-
R	S	14	L	16.00	1.50	29.0	10.81	-	-	6.93	4.10	2.83	-
R	S	30	L	16.00	1.52	24.0	9.48	-	-	6.25	2.28	3.97	-
R	S	22	L	18.25	0.50	26.0	8.74	-	-	6.40	2.20	4.20	-
R	S	1-266	E	21.00	0.00	16.5	7.41	-	-	7.50	4.30	3.20	-
R	S	82-34	E	22.75	0.50	22.0	5.19	-	-	8.33	3.65	4.68	-
R	S	82-14	E	22.50	2.00	19.0	8.15	-	-	8.33	3.00	5.33	-
R	S	81-54	E	22.50	1.00	22.0	11.26	-	-	7.90	2.93	4.97	-
R	S	81-52	E	22.70	4.50	17.0	6.37	-	-	5.55	2.20	3.35	-
R	S	81-72	E	22.50	0.00	18.0	5.63	-	-	7.50	2.70	4.80	-
R	S	81-73	E	26.50	5.50	17.0	4.89	-	-	7.75	2.70	5.05	-
R	S	1-267	E	32.50	0.01	28.5	11.26	-	-	6.93	4.10	2.83	-
R	S	81-59	E	20.00	DEAD	9.0	2.00	-	-	4.15	1.40	2.75	-
R	S	81-55	E	26.50	1.50	22.0	8.74	-	-	6.93	2.70	4.23	-
R	S	81-51	E	26.70	0.50	22.5	8.30	-	-	7.08	4.60	2.48	-
R	S	273	R	25.50	1.50	23.7	9.63	-	-	7.75	3.15	4.60	-
R	S	81-03	R	24.00	3.00	23.0	8.44	-	-	7.75	3.65	4.10	-
R	S	344	R	24.50	3.00	26.2	10.67	-	-	8.33	3.80	4.53	-
R	S	1-269	R	32.50	0.16	26.2	10.52	-	-	8.33	3.95	4.38	-
R	S	334	R	39.50	0.00	28.5	11.41	-	-	7.63	4.30	3.33	-
T	S	230N	E	20.50	4.00	25.0	10.15	9.90	20.35	6.53	2.45	4.08	1.8770
T	S	233N	E	18.25	6.00	18.5	7.23	7.13	13.60	7.50	2.35	5.15	0.7650
T	S	234N	E	17.50	23.50	17.0	5.93	5.96	18.35	5.55	2.05	3.50	0.7650
T	S	237N	E	16.75	11.00	20.5	8.62	7.19	15.90	5.95	1.85	4.10	1.5290
T	S	39N	L	16.25	3.00	18.5	7.69	6.86	20.00	6.65	2.35	4.30	0.9730
T	S	45N	E	25.25	6.00	27.2	10.77	10.18	15.05	5.55	2.85	2.70	0.4870
T	S	46N	E	25.50	6.50	27.2	10.77	10.18	15.05	6.10	2.50	3.60	0.8340
T	S	229N	E	25.25	9.00	19.5	9.08	6.91	23.55	6.93	2.35	4.58	-
T	S	53N	E	26.50	1.00	22.7	8.00	8.09	16.00	7.75	2.85	4.90	0.2090
T	S	226N	L	18.50	4.50	26.7	10.37	9.86	13.35	5.83	3.15	2.68	0.6260
T	S	231N	R	19.50	10.50	20.2	6.07	8.30	13.90	7.50	2.85	4.65	1.8777
T	S	235N	L	11.50	3.70	14.0	7.41	3.49	17.90	5.83	2.50	3.33	0.2090
S	G	84-32	K	10.00	0.08	27.0	8.97	-	-	7.20	3.90	3.30	-
S	G	84-18	K	11.50	1.00	25.0	9.10	-	-	8.33	3.90	4.43	-
S	G	185	K	9.00	3.00	18.0	6.48	-	-	8.60	3.35	5.25	-
S	G	214	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	49	K	13.00	0.00	26.2	9.52	-	-	9.03	3.50	5.53	-
S	G	217	K	10.50	0.16	23.0	7.06	-	-	9.15	3.35	5.80	-
S	G	204	K	15.50	0.50	24.2	8.69	-	-	7.90	3.90	4.00	-
S	G	6	K	19.00	0.02	26.0	9.38	-	-	7.63	4.03	3.60	-
S	G	145	K	14.00	0.50	26.5	9.66	-	-	8.33	3.50	4.83	-
S	G	201	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	184	D	18.75	1.50	27.0	9.52	-	-	7.20	3.50	3.70	-
S	G	104	D	15.00	1.00	25.0	7.72	-	-	8.05	2.78	5.27	-
S	G	39	D	18.25	0.50	24.0	6.90	-	-	7.90	-	-	-
S	G	193	B	21.00	0.50	28.7	9.52	-	-	1.93	3.63	4.27	-
S	G	107	D	18.50	1.00	24.0	8.54	-	-	8.33	3.45	4.88	-
S	G	110	D	20.00	1.00	23.0	6.90	-	-	8.90	3.50	5.40	-
S	G	146	D	17.50	3.50	24.0	8.83	-	-	9.50	3.83	5.67	-
S	G	140	D	24.50	1.00	26.2	8.68	-	-	8.60	3.55	5.05	-
S	G	121	D	22.00	N.A.	20.7	6.48	-	-	8.90	2.48	6.42	-
S	G	125	D	22.00	0.01	26.5	9.66	-	-	8.90	3.70	5.20	-
S	G	84-15	K	9.25	1.50	24.0	5.69	-	-	9.30	3.25	6.05	-
R	G	210	K	DEAD	-	-	-	-	-	DEAD	-	-	-
R	G	215	K	10.00	5.00	24.0	3.93	-	-	8.75	3.50	5.25	-
R	G	192	K	12.00	1.00	24.0	7.32	-	-	8.33	3.35	4.98	-
R	G	216	K	12.00	0.50	25.5	7.73	-	-	9.80	2.98	6.82	-
R	G	213	K	DEAD	-	-	-	-	-	DEAD	-	-	-
R	G	183	K	16.50	0.00	24.0	7.73	-	-	7.63	2.48	5.15	-
R	G	194	K	12.50	1.00	25.0	8.68	-	-	7.63	3.45	4.18	-
R	G	202	K	14.00	3.00	27.5	10.58	-	-	9.60	3.10	6.50	-
R	G	117	K	15.25	1.00	26.0	8.68	-	-	7.90	2.25	5.65	-
R	G	111	D	14.50	2.50	28.0	9.36	-	-	8.33	3.05	5.28	-
R	G	15	B	17.00	0.12	27.0	8.68	-	-	9.80	3.50	6.30	-
R	G	127	D	18.50	2.00	26.0	9.76	-	-	7.35	3.30	4.05	-
R	G	122	B	19.00	1.50	20.0	6.78	-	-	8.75	2.25	6.50	-
R	G	144	D	16.50	0.50	21.0	7.59	-	-	6.65	3.45	3.20	-
R	G	137	D	20.50	0.15	24.7	9.08	-	-	7.60	3.35	4.25	-
R	G	105	D	21.00	0.00	25.0	9.36	-	-	8.05	2.98	5.07	-
R	G	130	D	23.50	1.50	23.2	8.68	-	-	6.93	2.85	4.08	-
R	G	115	D	19.25	1.50	21.0	8.00	-	-	7.90	2.73	5.17	-
R	G	101	D	22.50	0.50	25.7	8.27	-	-	9.03	2.73	6.30	-
T	G	3	D	22.75	0.11	22.5	8.00	10.43	19.90	6.65	2.13	4.52	1.3900
T	G	4	D	21.25	1.00	26.5	9.23	12.38	18.00	7.50	2.85	4.65	0.3480
T	G	5	D	16.50	2.50	24.0	8.92	11.43	31.10	5.95	2.30	3.65	0.6260
T	G	7	D	18.00	2.00	24.5	8.77	11.28	31.75	6.65	2.78	3.87	1.3900
T	G	8	D	19.50	2.00	22.0	8.15	8.62	22.25	6.93	2.25	4.68	0.7650
T	G	9	B	14.25	2.50	25.0	9.08	9.54	29.65	8.05	2.30	5.75	0.2090
T	G	12	K	9.00	2.50	19.0	6.77	6.91	14.70	7.50	2.25	5.25	0.0000
T	G	15	B	19.50	0.04	22.0	8.15	11.60	19.30	7.63	2.48	5.15	1.8770
T	G	16	K	18.50	2.00	23.0	8.89	11.69	12.30	7.35	2.58	4.77	1.1120
T	G	18	D	25.00	10.00	15.7	7.08	7.47	23.70	8.05	2.58	5.47	0.3480
T	G	19	D	22.50	1.50	13.0	4.74	7.73	16.25	5.83	1.65	4.18	3.3360
T	G	20	K	11.50	11.50	20.0	7.56	9.96	19.10	7.20	2.58	4.62	1.4600
T	G	22	K	18.00	5.50	22.7	8.77	10.82	14.00	7.50	2.98	4.52	-
T	G	23	D	23.00	4.00	N.A.	-	-	-	N.A.	-	-	-
T	G	24	K	18.00	2.00	23.7	8.46	11.87	13.35	6.65	2.98	3.67	0.4170
T	G	25	K	10.75	7.00	20.5	8.62	11.10	16.85	6.10	2.98	3.12	0.6260
T	G	42	K	12.50	13.00	25.0	9.48	9.84	23.75	7.20	2.85	4.35	-
T	G	48	D	24.00	1.00	22.0	9.08	9.36	13.05	9.50	1.93	7.57	0.0000

APPENDIX 3

DATA FOR MID-JUNE 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	14.50	0.00
S	S	17	L	DEAD	-
S	S	11	L	13.00	0.50
S	S	16	L	16.25	1.50
S	S	6	L	19.75	0.50
S	S	84-08	E	22.00	0.50
S	S	1-261	E	22.00	0.00
S	S	81-64	E	DEAD	-
S	S	81-68	E	23.75	0.00
S	S	82-27	E	24.00	0.00
S	S	81-71	E	24.25	0.50
S	S	82-23	E	22.75	0.50
S	S	82-33	E	23.50	0.02
S	S	81-58	E	22.00	0.50
S	S	84-10	E	21.00	1.00
S	S	82-26	E	24.75	0.00
S	S	284	R	25.75	5.50
S	S	329	R	27.00	0.16
S	S	307	R	30.00	0.50
S	S	84-09	R	29.75	3.50
S	S	84-11	R	35.75	0.01
R	S	23	L	16.50	6.00
R	S	7	L	14.75	0.05
R	S	14	L	16.00	1.50
R	S	30	L	15.75	0.50
R	S	22	L	18.75	0.50
R	S	1-266	E	21.50	0.00
R	S	82-34	E	22.75	3.00
R	S	82-14	E	22.50	6.00
R	S	81-54	E	22.50	0.50
R	S	81-52	E	22.75	5.00
R	S	81-72	E	22.75	2.50
R	S	81-73	E	26.75	6.00
R	S	1-267	E	30.00	0.50
R	S	81-59	E	DEAD	-
R	S	81-55	E	27.00	0.50
R	S	81-51	E	27.50	3.00
R	S	273	R	25.50	0.50
R	S	81-03	R	24.25	5.00
R	S	344	R	24.00	0.50
R	S	1-269	R	32.75	0.50
R	S	334	R	39.50	0.00
S	G	84-32	K	10.75	2.00
S	G	84-18	K	11.50	5.50
S	G	185	K	9.00	4.00
S	G	214	K	DEAD	-
S	G	49	K	13.25	3.50
S	G	217	K	13.50	1.00
S	G	204	K	16.50	1.50
S	G	6	K	16.25	5.00
S	G	145	K	13.25	0.50
S	G	201	K	DEAD	-
S	G	184	D	17.25	2.00
S	G	104	D	15.50	4.00
S	G	39	D	18.00	6.00
S	G	193	B	21.25	1.00
S	G	107	D	18.75	1.00
S	G	110	D	20.50	4.00
S	G	146	D	17.50	4.50
S	G	140	D	25.25	4.00
S	G	121	D	18.75	5.50
S	G	125	D	23.25	1.00
R	G	84-15	K	9.50	7.50
R	G	210	K	DEAD	-
R	G	215	K	10.75	40.00
R	G	192	K	12.50	23.00
R	G	216	K	12.75	15.00
R	G	213	K	DEAD	-
R	G	183	K	14.75	2.00
R	G	194	K	13.25	5.00
R	G	202	K	15.25	17.50
R	G	117	K	16.75	5.50
R	G	111	D	15.25	19.50
R	G	15	B	18.75	15.50
R	G	127	D	17.25	10.00
R	G	122	B	18.75	3.00
R	G	144	D	17.00	2.50
R	G	137	D	18.25	6.50
R	G	105	D	22.75	1.00
R	G	130	D	19.75	14.50
R	G	115	D	21.00	9.00
R	G	101	D	22.00	4.00

APPENDIX 3

DATA FOR THE END OF JUNE 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	SERUM PEPSINOGEN (I.U.)
S	S	25	L	17.00	0.00	31.5	12.27	12.21	9.15	6.65	4.10	2.55	1.1120
S	S	17	L	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	11	L	15.75	0.50	26.7	10.13	8.67	8.40	7.35	3.70	3.65	1.9460
S	S	16	L	17.00	0.50	26.2	8.80	7.94	11.65	6.80	3.15	3.65	0.6260
S	S	6	L	21.50	0.01	26.5	11.73	9.01	11.20	7.08	4.30	2.78	0.8340
S	S	84-08	E	23.00	1.00	30.2	10.67	9.26	16.45	7.63	3.45	4.18	1.1820
S	S	1-261	E	22.00	0.50	22.0	8.53	8.53	15.45	8.33	3.15	5.18	0.4870
S	S	81-64	E	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	81-68	E	27.00	0.04	30.5	12.27	9.28	8.75	8.75	4.95	3.80	0.3480
S	S	82-27	E	25.50	0.00	25.7	9.33	7.94	16.45	9.30	3.95	5.35	0.4870
S	S	81-71	E	25.00	1.00	24.5	9.49	7.99	10.15	7.90	2.93	4.97	0.0000
S	S	82-23	E	26.00	0.50	28.2	14.40	8.22	14.75	8.33	4.75	3.58	0.7650
S	S	82-33	E	25.00	0.00	27.0	9.60	10.11	15.80	7.63	4.30	3.33	0.6950
S	S	81-58	E	26.50	0.00	24.5	9.07	6.70	11.45	10.30	4.10	6.20	0.0560
S	S	84-10	E	23.50	1.00	30.2	10.13	8.39	9.75	7.90	2.93	4.97	-
S	S	82-26	E	24.50	0.00	26.5	10.13	9.17	15.70	8.33	4.10	4.23	0.5560
S	S	284	R	28.50	4.50	20.7	9.87	7.34	9.75	8.33	3.30	5.03	0.2090
S	S	329	R	31.00	0.01	31.5	11.47	9.38	7.85	8.18	4.50	3.68	2.9190
S	S	307	R	32.00	0.50	25.7	10.40	8.30	10.10	8.05	3.45	4.60	1.6680
S	S	84-09	R	32.50	3.50	32.0	12.53	11.31	10.50	8.60	4.05	4.55	1.3900
S	S	84-11	R	38.00	0.50	30.7	11.47	10.81	9.10	8.75	4.35	4.40	2.6410
R	S	23	L	19.00	6.00	17.5	6.40	4.35	13.40	6.85	3.55	3.30	0.4870
R	S	7	L	16.00	5.00	17.0	5.33	4.15	8.80	7.85	3.55	4.30	3.7530
R	S	14	L	17.25	0.50	31.0	10.40	9.91	13.05	7.95	3.25	4.07	1.2510
R	S	30	L	16.75	1.00	30.0	11.20	8.66	8.95	6.85	2.75	4.10	0.9730
R	S	22	L	21.00	1.50	26.0	9.60	9.12	11.65	6.30	3.15	3.15	1.5290
R	S	1-266	E	22.50	0.00	30.0	10.93	10.28	11.10	-	3.55	-	2.5020
R	S	82-34	E	26.00	1.00	25.5	9.33	9.07	6.70	7.95	3.70	4.25	1.1820
R	S	82-14	E	22.50	3.00	21.0	8.00	8.06	9.25	7.95	2.75	5.20	0.3480
R	S	81-54	E	26.50	1.50	26.0	9.33	8.67	8.75	8.35	3.10	5.25	0.2780
R	S	81-52	E	21.75	13.50	22.0	7.47	6.38	23.30	6.75	2.45	4.30	1.1120
R	S	81-72	E	24.50	4.50	19.0	7.73	5.16	9.40	7.40	2.50	4.90	0.4870
R	S	81-73	E	24.50	7.50	22.0	8.00	5.32	9.40	7.40	2.28	5.12	1.1120
R	S	1-267	E	24.50	0.05	27.0	9.33	9.28	9.05	7.85	3.10	4.75	0.7650
R	S	81-59	E	DEAD	-	-	-	-	-	DEAD	-	-	-
R	S	81-55	E	26.25	1.00	25.5	8.80	8.25	10.40	7.40	2.60	4.80	0.3480
R	S	81-51	E	29.50	0.50	23.5	8.53	8.67	8.25	7.30	4.20	3.10	1.1120
R	S	273	R	30.00	1.50	29.5	10.67	10.51	13.60	8.25	3.40	4.85	1.3900
R	S	81-03	R	28.00	5.00	26.0	8.53	10.12	7.05	7.58	3.25	4.33	0.7650
R	S	344	R	26.50	0.00	27.0	10.93	10.36	7.00	7.58	3.30	4.28	1.7380
R	S	1-269	R	32.00	1.50	30.0	11.47	11.12	11.45	7.70	3.55	4.15	1.5990
R	S	334	R	46.00	0.03	31.0	11.20	9.46	5.45	8.55	4.05	4.50	1.8770
T	S	230N	E	19.00	2.40	-	-	-	-	-	-	-	-
T	S	233N	E	17.50	7.00	-	-	-	-	-	-	-	-
T	S	234N	E	16.00	20.50	-	-	-	-	-	-	-	-
T	S	237N	E	17.25	6.00	-	-	-	-	-	-	-	-
T	S	39N	L	13.50	3.00	-	-	-	-	-	-	-	-
T	S	45N	E	19.50	14.00	-	-	-	-	-	-	-	-
T	S	46N	E	23.50	23.50	-	-	-	-	-	-	-	-
T	S	229N	E	DEAD	-	-	-	-	-	-	-	-	-
T	S	53N	E	23.00	6.00	-	-	-	-	-	-	-	-
T	S	226N	L	17.75	3.50	-	-	-	-	-	-	-	-
T	S	231N	R	19.25	10.50	-	-	-	-	-	-	-	-
T	S	235N	L	10.50	24.00	-	-	-	-	-	-	-	-
S	G	84-32	K	10.25	7.50	31.0	9.03	12.74	17.95	7.05	3.25	3.80	0.6260
S	G	84-18	K	12.50	3.00	29.2	9.03	12.31	17.90	9.75	2.20	7.55	0.8340
S	G	185	K	9.00	8.00	23.2	7.23	10.99	13.95	9.50	3.25	6.25	-
S	G	214	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	49	K	13.00	0.22	26.7	9.47	15.50	18.80	8.90	2.85	6.05	0.4170
S	G	217	K	12.75	4.50	25.2	9.47	15.56	10.40	8.90	3.25	5.65	0.4170
S	G	204	K	16.25	3.00	28.7	7.74	13.48	11.55	8.33	3.90	4.43	1.3900
S	G	6	K	14.75	1.50	30.7	9.55	12.32	24.60	8.05	3.05	5.00	0.9730
S	G	145	K	13.25	1.00	31.5	10.03	16.75	15.20	9.00	3.75	5.25	1.0430
S	G	201	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	184	D	15.25	2.00	22.5	8.14	11.63	14.50	9.00	2.85	6.15	1.0430
S	G	104	D	15.00	3.00	26.5	7.48	12.93	10.25	8.33	2.85	5.48	0.6950
S	G	39	D	17.75	7.50	25.5	11.39	16.20	12.90	8.33	3.50	4.83	0.4870
S	G	193	B	21.00	2.50	28.5	9.29	13.56	19.30	8.18	3.10	5.08	0.0000
S	G	107	D	18.25	9.00	23.7	8.26	10.66	11.05	8.33	3.35	4.98	0.2090
S	G	110	D	18.50	2.00	26.7	9.76	14.52	18.30	9.75	3.25	6.50	1.3210
S	G	146	D	15.75	8.00	26.0	8.52	11.24	11.65	8.60	3.25	5.35	0.4170
S	G	140	D	22.75	4.00	28.0	11.12	14.96	22.90	8.60	3.25	5.35	0.4170
S	G	121	D	18.00	5.00	19.5	8.03	11.22	12.30	8.33	2.73	5.60	0.1740
S	G	125	D	22.00	3.50	31.5	11.66	15.21	21.25	9.80	2.20	7.60	0.0000
R	G	84-15	K	9.25	50.50	15.5	5.51	9.35	10.80	8.18	2.98	5.20	1.5290
R	G	210	K	DEAD	-	-	-	-	-	DEAD	-	-	-
R	G	215	K	10.25	22.00	23.5	7.87	11.45	12.65	9.15	3.25	5.90	1.1120
R	G	192	K	12.00	46.50	23.0	8.66	11.56	15.20	8.90	3.75	5.15	1.7380
R	G	216	K	12.25	5.50	25.0	6.82	13.86	21.00	9.50	1.93	7.57	-
R	G	213	K	DEAD	-	-	-	-	-	DEAD	-	-	-
R	G	183	K	13.75	6.50	21.5	7.34	11.77	18.40	78.18	2.85	5.33	2.2240
R	G	194	K	13.00	15.00	28.5	9.97	14.66	20.90	8.05	3.63	4.42	0.1040
R	G	202	K	14.25	13.00	30.0	10.75	15.49	15.25	7.75	2.40	5.35	1.1120
R	G	117	K	16.00	15.00	26.5	10.23	11.80	14.10	7.50	3.25	4.25	0.9730
R	G	111	D	14.75	48.50	29.0	9.70	13.65	14.90	9.03	2.85	6.18	1.7380
R	G	15	B	18.25	42.00	27.0	9.44	11.21	11.65	9.70	3.55	6.15	-
R	G	127	D	16.25	24.00	26.0	9.70	12.12	18.30	8.33	-	-	1.5990
R	G	122	B	19.00	7.00	25.0	8.39	12.96	16.15	8.05	2.05	6.00	1.3210
R	G	144	D	17.00	8.00	26.5	9.97	11.90	14.30	7.20	3.18	4.02	0.9730
R	G	137	D	16.50	19.50	23.5	8.39	14.26	20.65	8.33	2.78	5.55	1.5990
R	G	105	D	22.75	0.50	24.0	10.75	10.96	14.35	8.90	2.85	6.05	1.8770
R	G	130	D	18.75	15.50	20.5	7.34	11.43	14.60	10.05	1.93	8.12	1.1120
R	G	115	D	20.00	14.50	20.0	8.13	7.03	13.15	8.75	2.30	6.45	1.1120
R	G	101	D	19.00	3.00	24.0	8.92	13.06	17.65	7.90	2.30	5.60	-
T	G	3	D	22.50	1.00	-	-	-	-	-	-	-	-
T	G	4	D	21.00	0.50	-	-	-	-	-	-	-	-
T	G	5	D	16.50	1.00	-	-	-	-	-	-	-	-
T	G	7	D	17.50	12.50	-	-	-	-	-	-	-	-
T	G	8	D	22.50	4.50	-	-	-	-	-	-	-	-
T	G	9	B	14.00	2.50	-	-	-	-	-	-	-	-
T	G	12	K	9.50	1.50	-	-	-	-	-	-	-	-
T	G	15	D	21.25	0.17	-	-	-	-	-	-	-	-
T	G	16	D	16.25	0.50	-	-	-	-	-	-	-	-
T	G	18	D	22.50	2.00	-	-	-	-	-	-	-	-
T	G	19	D	22.50	2.00	-	-	-	-	-	-	-	-
T	G	20	K	11.75	2.50	-	-	-	-	-	-	-	-
T	G	22	K	16.50	2.50	-	-	-	-	-	-	-	-
T	G	23	D	19.50	0.28	-	-	-	-	-	-	-	-
T	G	24	K	17.50	3.50	-	-	-	-	-	-	-	-
T	G	25	K	10.75	1.00	-	-	-	-	-	-	-	-
T	G	42	K	13.50	1.50	-	-	-	-	-	-	-	-
T	G	48	D	23.75	1.50	-	-	-	-	-	-	-	-

APPENDIX 3

DATA FOR MID-JULY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	18.25	0.00
S	S	17	L	DEAD	-
S	S	11	L	16.25	0.00
S	S	16	L	17.00	3.00
S	S	6	L	22.00	0.50
S	S	84-08	E	23.50	0.06
S	S	1-261	E	22.50	0.00
S	S	81-64	E	DEAD	-
S	S	81-68	E	27.50	0.50
S	S	82-27	E	26.75	0.03
S	S	81-71	E	24.00	6.50
S	S	82-23	E	26.25	0.50
S	S	82-33	E	26.25	0.00
S	S	81-58	E	27.25	0.00
S	S	84-10	E	24.00	0.50
S	S	82-26	E	25.25	0.00
S	S	284	R	30.00	8.50
S	S	329	R	32.00	0.01
S	S	307	R	33.50	0.50
S	S	84-09	R	33.00	8.50
S	S	84-11	R	39.50	3.50
R	S	23	L	19.00	3.50
R	S	7	L	16.25	2.00
R	S	14	L	23.00	0.04
R	S	30	L	16.75	0.00
R	S	22	L	21.00	0.50
R	S	1-266	E	22.25	0.03
R	S	82-34	E	26.00	0.50
R	S	82-14	E	22.25	3.00
R	S	81-54	E	26.75	0.50
R	S	81-52	E	20.00	6.50
R	S	81-72	E	26.00	5.00
R	S	81-73	E	24.25	1.50
R	S	1-267	E	24.00	0.00
R	S	81-59	E	DEAD	-
R	S	81-55	E	26.00	0.04
R	S	81-51	E	29.25	0.00
R	S	273	R	30.50	2.00
R	S	81-03	R	27.50	4.00
R	S	344	R	26.75	0.50
R	S	1-269	R	31.00	1.00
R	S	334	R	47.50	0.00
S	G	84-32	K	11.00	7.00
S	G	84-18	K	11.00	18.00
S	G	185	K	9.75	13.50
S	G	214	K	DEAD	-
S	G	49	K	13.25	3.50
S	G	217	K	13.50	12.00
S	G	204	K	15.75	1.00
S	G	6	K	14.50	4.50
S	G	145	K	13.00	2.50
S	G	201	K	DEAD	-
S	G	184	D	15.25	19.50
S	G	104	D	15.50	4.00
S	G	39	D	18.00	1.50
S	G	193	B	21.50	0.50
S	G	107	D	18.25	4.00
S	G	110	D	18.25	4.50
S	G	146	D	16.25	18.50
S	G	140	D	22.25	18.00
S	G	121	D	19.50	6.50
S	G	125	D	22.00	0.50
R	G	84-15	K	9.75	13.50
R	G	210	K	DEAD	-
R	G	215	K	11.00	18.50
R	G	192	K	12.25	34.50
R	G	216	K	12.50	4.00
R	G	213	K	DEAD	-
R	G	183	K	13.75	8.00
R	G	194	K	12.75	5.00
R	G	202	K	14.50	17.00
R	G	117	K	16.00	51.50
R	G	111	D	15.25	9.00
R	G	15	B	19.00	30.50
R	G	127	D	16.50	35.00
R	G	122	B	19.00	0.50
R	G	144	D	16.75	3.50
R	G	137	D	16.50	18.50
R	G	105	D	23.00	1.50
R	G	130	D	19.00	6.50
R	G	115	D	21.00	0.50
R	G	101	D	19.75	2.50

APPENDIX 3

DATA FOR THE END OF JULY 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl
S	S	25	L	19.00	0.01	30.5	11.20	6.75	3.88	2.87
S	S	17	L	DEAD	-	-	-	DEAD	-	-
S	S	11	L	16.50	0.03	28.0	9.87	7.40	3.25	4.15
S	S	16	L	17.00	4.00	21.5	7.47	6.40	2.28	4.12
S	S	6	L	22.75	0.07	28.0	10.13	6.75	2.93	3.82
S	S	84-08	E	23.50	0.00	28.0	10.13	7.40	3.40	4.00
S	S	1-261	E	23.00	0.00	22.0	8.00	7.85	3.15	4.70
S	S	81-64	E	DEAD	-	-	-	DEAD	-	-
S	S	81-68	E	29.00	0.09	35.0	12.27	9.25	3.55	5.70
S	S	82-27	E	28.00	0.03	26.0	9.07	8.35	4.05	4.30
S	S	81-71	E	24.00	7.00	24.0	8.80	7.30	2.28	5.02
S	S	82-23	E	27.75	1.00	33.0	10.93	8.55	3.55	5.00
S	S	82-33	E	27.00	0.03	26.2	10.40	7.00	3.40	3.60
S	S	81-58	E	29.00	0.00	21.5	7.73	9.50	3.25	6.25
S	S	84-10	E	24.75	0.50	25.0	9.87	7.58	3.00	4.58
S	S	82-26	E	26.00	0.01	26.0	10.13	7.70	3.00	4.70
S	S	284	R	30.00	1.85	18.0	8.27	7.30	2.93	4.37
S	S	329	R	33.00	0.50	29.5	9.60	7.85	3.88	3.97
S	S	307	R	34.00	2.00	27.0	9.33	8.35	2.45	5.90
S	S	84-09	R	33.00	8.00	38.0	12.53	9.35	4.05	5.30
S	S	84-11	R	41.00	2.50	29.0	12.00	7.95	3.70	4.25
R	S	23	L	18.00	1.50	25.0	8.00	7.40	3.25	4.15
R	S	7	L	16.75	0.50	25.7	9.33	6.60	3.70	2.90
R	S	14	L	18.00	0.00	31.5	10.67	7.95	3.70	4.25
R	S	30	L	17.00	0.00	30.0	10.13	6.60	2.93	3.67
R	S	22	L	21.00	1.00	28.5	9.33	6.60	3.25	3.35
R	S	1-266	E	23.50	0.50	27.5	9.87	7.00	3.25	3.75
R	S	82-34	E	27.25	0.00	23.5	9.60	N.A.	3.40	N.A.
R	S	82-14	E	22.50	1.00	22.0	7.20	7.85	2.93	4.92
R	S	81-54	E	28.00	0.50	26.0	10.56	8.25	3.25	5.00
R	S	81-52	E	21.50	1.00	18.0	5.60	7.00	2.75	4.25
R	S	81-72	E	25.00	0.07	17.0	5.87	7.00	2.45	4.55
R	S	81-73	E	25.00	0.50	23.7	7.73	7.85	2.45	5.40
R	S	1-267	E	24.00	0.03	26.0	8.80	6.60	2.60	4.00
R	S	81-59	E	DEAD	-	-	-	DEAD	-	-
R	S	81-55	E	29.00	0.01	25.5	8.53	6.85	2.28	4.57
R	S	81-51	E	29.75	0.03	26.5	9.33	6.60	3.55	3.05
R	S	273	R	31.25	0.50	27.0	9.87	6.60	3.40	3.20
R	S	81-03	R	27.50	1.00	22.7	7.89	7.70	3.40	4.30
R	S	344	R	25.75	0.50	14.0	3.73	7.70	N.A.	N.A.
R	S	1-269	R	32.00	1.00	23.2	8.53	7.85	N.A.	N.A.
R	S	334	R	46.75	0.00	24.0	7.47	9.25	3.25	6.00
T	S	230N	E	DEAD	-	-	-	-	-	-
T	S	233N	E	19.00	3.00	-	-	-	-	-
T	S	234N	E	DEAD	-	-	-	-	-	-
T	S	237N	E	N.A.	-	-	-	-	-	-
T	S	39N	L	13.25	1.00	-	-	-	-	-
T	S	45N	E	DEAD	-	-	-	-	-	-
T	S	46N	E	DEAD	-	-	-	-	-	-
T	S	229N	E	DEAD	-	-	-	-	-	-
T	S	53N	E	20.00	8.50	-	-	-	-	-
T	S	226N	L	17.25	5.00	-	-	-	-	-
T	S	231N	R	19.25	4.50	-	-	-	-	-
T	S	235N	L	10.75	45.50	-	-	-	-	-
S	G	84-32	K	11.00	9.50	26.0	9.44	8.18	3.05	5.13
S	G	84-18	K	11.00	10.00	25.0	8.92	9.30	2.58	6.72
S	G	185	K	10.00	40.00	22.5	7.34	8.60	2.58	6.02
S	G	214	K	DEAD	-	-	-	DEAD	-	-
S	G	49	K	13.25	9.50	25.5	8.92	8.90	2.65	6.25
S	G	217	K	13.00	21.50	21.5	5.89	8.90	2.30	6.60
S	G	204	K	15.25	1.50	27.0	9.70	7.63	2.85	4.78
S	G	6	K	15.00	3.00	24.0	9.18	9.30	2.48	6.82
S	G	145	K	12.00	1.50	22.0	7.61	9.80	1.93	7.87
S	G	201	K	DEAD	-	-	-	DEAD	-	-
S	G	184	D	14.50	49.50	18.0	9.44	9.80	1.93	7.87
S	G	104	D	15.00	6.00	25.0	8.92	8.18	2.05	6.13
S	G	39	D	18.50	5.50	23.5	8.39	8.05	2.58	5.47
S	G	193	B	20.50	1.50	30.0	9.70	9.00	2.40	6.60
S	G	107	D	18.25	2.50	21.5	7.61	7.63	2.13	5.50
S	G	110	D	18.00	9.50	26.5	7.87	9.15	2.20	6.95
S	G	146	D	15.75	23.50	24.0	7.47	9.15	2.48	6.67
S	G	140	D	20.50	12.00	20.5	6.82	8.90	1.65	7.25
S	G	121	D	19.50	16.50	18.0	6.03	8.90	2.20	6.70
S	G	125	D	22.50	2.00	25.5	8.66	9.90	2.53	7.37
R	G	84-15	K	10.00	9.00	16.0	8.53	10.30	2.13	8.17
R	G	210	K	DEAD	-	-	-	DEAD	-	-
R	G	215	K	10.50	18.50	24.5	6.93	8.80	2.85	5.95
R	G	192	K	12.00	27.00	21.0	12.80	8.95	2.53	6.42
R	G	216	K	12.50	1.00	25.0	6.93	8.13	2.00	6.13
R	G	213	K	DEAD	-	-	-	DEAD	-	-
R	G	183	K	13.50	15.50	23.5	7.47	8.80	2.53	6.27
R	G	194	K	12.50	8.00	25.5	8.27	9.70	3.30	6.40
R	G	202	K	14.25	10.50	22.0	7.47	8.13	2.40	5.73
R	G	117	K	15.50	9.00	25.0	9.33	7.85	2.53	5.32
R	G	111	D	14.75	36.00	26.5	8.53	9.70	2.40	7.30
R	G	15	B	17.25	69.50	24.5	6.67	8.40	2.53	5.87
R	G	127	D	16.00	40.00	26.0	8.00	7.70	2.65	5.05
R	G	122	B	19.00	0.50	29.0	8.80	8.70	1.60	7.10
R	G	144	D	16.75	4.50	24.0	7.20	6.75	2.78	3.97
R	G	137	D	15.50	13.00	18.0	5.87	7.85	2.13	5.72
R	G	105	D	24.75	0.50	23.0	8.53	8.35	2.40	5.95
R	G	130	D	18.00	22.50	22.0	10.67	10.30	2.00	8.30
R	G	115	D	19.25	7.00	20.0	6.13	8.13	2.40	5.73
R	G	101	D	19.00	5.00	19.0	5.33	7.95	1.73	6.22
T	G	3	D	21.50	0.50	-	-	-	-	-
T	G	4	D	21.25	5.50	-	-	-	-	-
T	G	5	D	17.00	0.50	-	-	-	-	-
T	G	7	D	17.00	1.00	-	-	-	-	-
T	G	8	D	18.25	1.00	-	-	-	-	-
T	G	9	B	14.00	1.00	-	-	-	-	-
T	G	12	K	11.75	2.50	-	-	-	-	-
T	G	15	D	22.50	0.03	-	-	-	-	-
T	G	16	D	15.75	0.50	-	-	-	-	-
T	G	18	D	21.25	12.50	-	-	-	-	-
T	G	19	D	22.00	1.00	-	-	-	-	-
T	G	20	K	12.50	0.50	-	-	-	-	-
T	G	22	K	14.75	1.00	-	-	-	-	-
T	G	23	D	18.50	1.50	-	-	-	-	-
T	G	24	K	16.00	0.11	-	-	-	-	-
T	G	25	K	10.25	1.00	-	-	-	-	-
T	G	42	K	13.25	3.00	-	-	-	-	-
T	G	48	D	23.00	1.00	-	-	-	-	-

APPENDIX 3

DATA FOR THE END OF AUGUST 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)	SERUM PEPSINOGEN (i.u.)
S	S	25	L	21.00	0.00	30.0	6.40	-	-	6.93	3.80	3.13	0.7650
S	S	17	L	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	11	L	18.00	0.00	27.5	8.80	-	-	6.80	2.35	4.45	2.2940
S	S	16	L	17.50	0.50	20.5	10.13	-	-	6.53	2.18	4.35	1.1820
S	S	6	L	24.25	0.00	26.0	8.27	-	-	7.20	3.65	3.55	3.1970
S	S	84-08	E	24.50	0.01	25.5	8.96	-	-	8.05	3.45	4.60	1.3900
S	S	1-261	E	24.00	0.01	28.5	7.20	-	-	8.33	3.00	5.33	0.4870
S	S	81-64	E	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	81-68	E	27.00	0.50	27.0	8.80	-	-	7.63	3.70	3.93	1.6680
S	S	82-27	E	26.50	2.00	30.0	10.40	-	-	7.50	3.80	3.70	1.5290
S	S	81-71	E	24.00	0.00	26.5	7.20	-	-	7.50	2.45	5.05	0.0000
S	S	82-23	E	29.50	2.50	26.5	8.27	-	-	6.93	3.80	3.13	0.9730
S	S	82-33	E	29.00	0.00	28.5	9.87	-	-	N.A.	3.80	-	0.2085
S	S	81-58	E	32.00	0.50	26.0	6.67	-	-	8.90	3.30	5.60	6.8110
S	S	84-10	E	23.00	2.00	25.0	7.73	-	-	7.35	3.25	4.10	1.1120
S	S	82-26	E	27.00	0.00	27.5	9.33	-	-	7.08	3.70	3.38	0.7650
S	S	284	R	30.00	8.50	18.0	5.97	-	-	7.35	2.75	4.60	0.1040
S	S	329	R	33.00	0.50	26.5	8.80	-	-	7.75	3.65	4.10	2.1550
S	S	307	R	29.50	2.00	28.0	9.49	-	-	8.75	2.45	6.30	0.6260
S	S	84-09	R	DEAD	-	-	-	-	-	DEAD	-	-	-
S	S	84-11	R	41.50	0.50	31.0	5.33	-	-	7.63	3.45	4.18	1.7380
R	S	23	L	19.50	2.50	23.5	9.60	-	-	6.93	2.93	4.00	3.4750
R	S	7	L	17.00	0.50	20.0	6.40	-	-	6.10	3.10	3.00	0.9730
R	S	14	L	18.50	2.00	31.5	9.60	-	-	7.50	3.40	4.10	3.3360
R	S	30	L	19.00	0.00	31.5	9.60	-	-	7.50	3.70	3.80	1.1820
R	S	22	L	23.00	0.00	29.0	6.93	-	-	6.80	3.40	3.40	2.0160
R	S	1-266	E	25.00	0.00	31.0	9.60	-	-	5.40	3.88	1.52	0.7650
R	S	82-34	E	25.00	1.50	25.0	10.67	-	-	7.20	3.80	3.40	2.7800
R	S	82-14	E	24.50	1.00	22.5	7.47	-	-	7.90	3.25	4.65	2.2240
R	S	81-54	E	25.00	3.50	26.5	9.87	-	-	7.90	3.88	4.02	2.7800
R	S	81-52	E	16.00	10.00	DIED	-	-	-	DEAD	-	-	-
R	S	81-72	E	26.00	0.50	20.0	8.80	-	-	7.50	2.93	4.57	0.2780
R	S	81-73	E	25.25	0.00	22.0	8.59	-	-	7.50	2.75	4.75	1.5985
R	S	1-267	E	25.50	0.00	29.0	9.07	-	-	8.33	3.40	4.93	0.1040
R	S	81-59	E	DEAD	-	-	-	-	-	DEAD	-	-	-
R	S	81-55	E	29.50	0.03	29.5	10.40	-	-	7.08	3.10	3.98	0.7650
R	S	81-51	E	32.50	0.50	23.5	9.60	-	-	7.35	4.20	3.15	0.9040
R	S	273	R	32.00	0.50	27.5	9.49	-	-	8.60	4.05	4.55	1.1820
R	S	81-03	R	28.00	1.50	27.0	7.20	-	-	7.35	3.70	3.65	0.9730
R	S	344	R	27.75	1.00	29.0	8.00	-	-	7.75	3.40	4.35	1.0430
R	S	1-269	R	35.00	2.00	24.0	7.57	-	-	8.05	3.55	4.50	1.1120
R	S	334	R	50.00	0.00	31.0	10.40	-	-	8.05	4.20	3.85	1.5290
T	S	230N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	233N	E	15.00	N.A.	16.0	5.42	6.08	12.75	7.15	2.50	4.65	0.2090
T	S	234N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	237N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	39N	L	13.50	1.00	25.0	8.00	6.98	9.00	7.70	3.00	4.70	0.2090
T	S	45N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	46N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	229N	E	DEAD	-	-	-	-	-	DEAD	-	-	-
T	S	53N	E	19.75	16.00	11.0	4.39	3.50	15.40	5.18	1.85	3.33	0.0560
T	S	226N	L	17.00	5.00	18.5	6.19	6.71	11.75	7.00	3.00	4.00	0.0000
T	S	231N	R	19.75	4.50	21.0	7.23	6.58	13.85	8.80	3.15	5.65	0.2090
T	S	235N	L	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	84-32	K	12.00	18.00	31.0	8.53	-	-	9.75	2.40	7.35	0.9730
S	G	84-18	K	11.25	8.50	20.7	5.87	-	-	8.90	1.93	6.97	0.6255
S	G	185	K	10.50	6.00	26.5	7.47	-	-	9.00	3.18	5.82	1.5290
S	G	214	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	49	K	14.50	1.00	26.5	8.27	-	-	9.00	3.10	5.90	1.1815
S	G	217	K	12.75	5.50	23.7	6.83	-	-	9.50	2.30	7.20	1.8765
S	G	204	K	16.75	0.50	28.0	7.73	-	-	9.30	3.63	5.67	1.5290
S	G	6	K	15.00	3.00	26.7	8.00	-	-	9.00	2.65	6.35	0.9035
S	G	145	K	13.25	1.00	27.7	5.33	-	-	9.75	3.10	6.65	0.6255
S	G	201	K	DEAD	-	-	-	-	-	DEAD	-	-	-
S	G	184	D	15.00	18.50	26.0	5.60	-	-	9.50	2.58	6.92	0.6950
S	G	104	D	15.50	9.50	26.2	5.33	-	-	8.90	2.30	6.60	1.3900
S	G	39	D	18.00	3.50	24.0	6.40	-	-	9.00	2.20	6.80	1.2510
S	G	193	B	21.50	2.00	30.0	8.00	-	-	9.75	2.98	6.77	-
S	G	107	D	19.50	1.50	24.0	5.33	-	-	8.60	2.78	5.82	0.7650
S	G	110	D	18.00	1.50	26.2	7.47	-	-	9.90	2.48	7.42	0.7645
S	G	146	D	16.25	4.00	26.5	7.57	-	-	9.00	2.53	6.47	0.1737
S	G	140	D	22.50	3.50	25.5	8.53	-	-	9.30	2.13	7.17	1.1120
S	G	121	D	20.00	4.50	21.2	6.67	-	-	9.30	2.20	7.10	1.1120
S	G	125	D	23.00	0.03	25.5	6.40	-	-	9.80	2.73	7.07	-
R	G	84-15	K	10.25	22.50	11.2	2.93	-	-	9.70	2.25	7.45	1.3900
R	G	210	K	DEAD	-	-	-	-	-	DEAD	-	-	-
R	G	215	K	10.00	6.50	18.5	4.80	-	-	9.00	2.30	6.70	0.3480
R	G	192	K	12.50	19.50	14.0	3.73	-	-	8.33	2.65	5.68	1.6680
R	G	216	K	11.75	5.00	25.2	7.73	-	-	9.15	2.05	7.10	0.3480
R	G	213	K	-	-	-	-	-	-	DEAD	-	-	-
R	G	183	K	13.50	4.50	20.7	6.45	-	-	8.90	1.80	7.10	1.6680
R	G	194	K	13.75	7.50	24.5	8.00	-	-	8.33	2.98	5.35	0.3480
R	G	202	K	15.75	9.50	28.5	5.60	-	-	8.60	2.30	6.30	1.1120
R	G	117	K	17.50	3.00	25.5	7.20	-	-	8.90	3.10	5.80	1.6680
R	G	111	D	15.75	19.00	25.5	6.67	-	-	9.80	2.20	7.60	5.0040
R	G	15	B	15.75	27.00	20.2	9.33	-	-	7.90	2.30	5.60	1.3900
R	G	127	D	15.25	44.00	18.5	5.33	-	-	8.33	2.30	6.03	1.8770
R	G	122	B	20.25	0.50	29.0	8.00	-	-	8.80	2.20	6.60	4.0310
R	G	144	D	18.00	1.00	24.2	7.57	-	-	6.93	2.85	4.08	0.4870
R	G	137	D	16.50	12.00	19.5	5.87	-	-	9.00	2.48	6.52	2.4330
R	G	105	D	24.50	2.50	25.0	7.73	-	-	7.85	3.10	4.75	-
R	G	130	D	18.50	6.50	23.5	6.40	-	-	11.20	2.00	9.20	-
R	G	115	D	20.25	1.50	21.2	7.47	-	-	8.33	2.30	6.03	-
R	G	101	D	19.25	0.29	18.5	5.33	-	-	10.30	2.00	8.30	1.8770
T	G	3	D	22.75	1.50	21.0	7.74	9.89	19.30	8.13	2.85	5.28	1.0430
T	G	4	D	24.25	1.50	25.5	8.52	11.06	19.90	9.25	2.98	6.27	0.5560
T	G	5	D	18.25	1.50	24.5	8.52	9.92	17.40	8.25	3.05	5.20	0.4870
T	G	7	D	18.50	0.24	26.0	9.03	11.24	21.90	7.85	2.98	4.87	1.0430
T	G	8	D	18.00	4.00	21.5	7.48	9.17	24.75	9.25	2.30	6.95	1.1120
T	G	9	B	15.00	2.00	23.0	8.00	10.30	18.35	8.25	3.10	5.15	0.5560
T	G	12	K	12.00	0.04	23.5	9.29	10.32	12.55	7.70	2.85	4.85	0.1040
T	G	15	D	23.75	0.50	23.0	8.26	9.11	14.05	7.85	N.A.	-	N.A.
T	G	16	D	16.75	0.11	26.5	9.81	9.50	19.55	7.70	2.98	4.72	0.4870
T	G	18	D	DEAD	-	-	-	-	-	DEAD	-	-	-
T	G	19	D	25.00	0.03	17.5	6.45	7.68	15.25	7.58	2.65	4.93	0.7650
T	G	20	K	13.25	1.00	17.5	6.19	7.64	16.15	8.50	2.73	5.77	0.4170
T	G	22	K	15.00	1.00	22.5	6.71	10.11	13.15	8.70	3.10	5.60	0.6950
T	G	23	D	17.00	5.50	19.0	6.71	9.08	19.55	7.58	2.48	5.10	0.1040
T	G	24	K	16.00	0.50	22.0	5.68	9.94	8.10	6.75	2.85	3.90	0.8340
T	G	25	K	10.00	1.00	21.0	7.23	9.27	13.95	7.40	2.98	4.42	0.2090
T	G	42	K	1.35	0.00	25.0	8.77	13.05	19.40	7.85	2.90	4.95	-
T	G	48	D	23.25	0.50	20.0	6.19	9.59	15.35	9.70	2.48	7.22	0.4170

APPENDIX 3

DATA FOR MID-SEPTEMBER 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	21.50	0.00
S	S	17	L	DEAD	-
S	S	11	L	18.50	0.00
S	S	16	L	17.50	3.50
S	S	6	L	25.00	0.00
S	S	84-08	E	25.50	0.50
S	S	1-261	E	25.50	0.00
S	S	81-64	E	DEAD	-
S	S	81-68	E	27.50	5.50
S	S	82-27	E	27.00	25.00
S	S	81-71	E	24.50	1.00
S	S	82-23	E	26.00	6.00
S	S	82-33	E	30.50	0.01
S	S	81-58	E	32.00	2.00
S	S	84-10	E	22.50	31.50
S	S	82-26	E	28.00	0.50
S	S	284	R	30.50	59.50
S	S	329	R	33.50	0.00
S	S	307	R	27.00	CULLED
S	S	84-09	R	DEAD	-
S	S	84-11	R	42.50	6.50
R	1	23	L	20.00	6.50
R	S	7	L	17.50	2.00
R	S	14	L	19.00	0.50
R	S	30	L	19.50	0.00
R	S	22	L	23.50	0.00
R	S	1-266	E	25.50	0.01
R	S	82-34	E	25.00	11.50
R	S	82-14	E	25.00	1.50
R	S	81-54	E	25.00	19.50
R	S	81-52	E	DEAD	-
R	S	81-72	E	26.50	4.00
R	S	81-73	E	26.00	3.50
R	S	1-267	E	26.50	0.50
R	S	81-59	E	DEAD	-
R	S	81-55	E	26.50	4.00
R	S	81-51	E	33.00	0.01
R	S	273	R	33.00	4.50
R	S	81-03	R	29.00	3.50
R	S	344	R	28.00	0.50
R	S	1-269	R	36.00	10.50
R	S	334	R	50.50	0.00
S	G	84-32	K	12.00	27.50
S	G	84-18	K	11.00	25.00
S	G	185	K	10.00	3.00
S	G	214	K	DEAD	-
S	G	49	K	14.00	1.50
S	G	217	K	13.00	10.00
S	G	204	K	16.50	0.50
S	G	6	K	14.00	7.50
S	G	145	K	13.25	2.00
S	G	201	K	DEAD	-
S	G	184	D	14.00	15.00
S	G	104	D	16.00	0.50
S	G	39	D	18.00	1.50
S	G	193	B	22.75	2.50
S	G	107	D	18.75	2.00
S	G	110	D	17.50	2.00
S	G	146	D	16.00	6.50
S	G	140	D	21.00	1.00
S	G	121	D	20.00	2.00
S	G	125	D	23.25	0.03
R	G	84-15	K	8.00	1.50
R	G	210	K	DEAD	-
R	G	215	K	11.00	14.50
R	G	192	K	12.00	11.50
R	G	216	K	12.25	1.00
R	G	213	K	DEAD	-
R	G	183	K	12.75	14.50
R	G	194	K	12.75	2.50
R	G	202	K	15.00	8.00
R	G	117	K	1.17	9.50
R	G	111	D	15.25	30.00
R	G	15	B	16.25	22.50
R	G	127	D	13.00	90.50
R	G	122	B	20.00	2.50
R	G	144	D	16.75	4.50
R	G	137	D	15.00	11.50
R	G	105	D	24.25	0.00
R	G	130	D	19.00	1.50
R	G	115	D	20.25	6.00
R	G	101	D	19.00	0.01

APPENDIX 3

DATA FOR THE END OF SEPTEMBER 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
S	S	25	L	23.00	0.00	28.2	9.60	-	-	6.65	3.45	3.20
S	S	17	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	11	L	19.25	0.00	28.0	9.35	-	-	5.95	3.45	2.50
S	S	16	L	18.25	0.04	24.0	7.88	-	-	5.83	2.45	3.38
S	S	6	L	25.50	3.50	26.7	8.36	-	-	6.10	4.10	2.00
S	S	84-08	L	25.00	8.50	27.7	9.11	-	-	7.48	3.70	3.78
S	S	1-261	L	25.50	0.00	25.2	8.62	-	-	6.53	3.65	2.88
S	S	81-64	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	81-68	L	26.50	2.00	26.5	9.35	-	-	7.48	3.55	3.93
S	S	82-27	L	27.00	6.50	24.5	8.37	-	-	6.65	3.65	3.00
S	S	81-71	L	23.50	0.00	23.5	7.38	-	-	7.35	3.45	3.90
S	S	82-23	L	26.00	3.50	25.0	9.11	-	-	6.25	3.30	2.95
S	S	82-33	L	31.00	0.00	29.0	10.58	-	-	6.53	3.45	3.08
S	S	81-58	L	27.50	0.00	24.7	8.86	-	-	7.48	2.93	4.55
S	S	84-10	L	22.50	0.00	23.7	8.12	-	-	6.65	3.15	3.50
S	S	82-26	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	284	R	31.50	4.50	21.7	7.14	-	-	5.83	2.75	3.08
S	S	329	R	34.50	0.00	28.5	9.85	-	-	7.20	4.10	3.10
S	S	307	R	CULLED	-	-	-	-	-	DEAD	-	-
S	S	84-09	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	84-11	L	43.00	4.50	26.5	9.35	-	-	6.80	3.88	2.92
S	S	23	L	20.50	1.00	23.2	8.37	-	-	5.70	3.10	2.60
S	S	7	L	18.00	0.00	21.0	7.88	-	-	5.55	3.25	2.30
S	S	14	L	19.00	0.00	26.7	8.62	-	-	6.40	3.88	2.52
S	S	30	L	20.00	0.00	31.0	9.11	-	-	6.93	3.70	3.23
S	S	22	L	24.00	0.00	26.5	7.47	-	-	5.90	3.30	2.60
S	S	1-266	L	27.00	0.00	26.2	9.35	-	-	6.40	3.70	2.70
S	S	82-34	L	25.50	1.00	19.5	6.65	-	-	6.80	3.15	3.65
S	S	82-14	L	25.50	0.00	21.5	7.63	-	-	6.10	2.93	3.17
S	S	81-54	L	25.50	0.00	23.7	7.38	-	-	7.48	3.15	4.33
S	S	81-52	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	81-72	L	27.00	1.00	19.7	6.89	-	-	6.40	2.93	3.47
S	S	81-73	L	26.50	0.00	26.5	9.11	-	-	7.20	3.00	4.20
S	S	1-267	L	26.50	0.00	21.7	7.38	-	-	6.65	3.55	3.10
S	S	81-59	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	81-55	L	27.00	0.50	19.5	5.42	-	-	7.20	2.75	4.45
S	S	81-51	L	31.00	0.00	21.5	8.12	-	-	5.25	4.05	1.90
S	S	273	R	33.50	0.50	27.5	10.09	-	-	7.20	3.95	3.25
S	S	81-03	L	29.50	0.03	24.5	7.88	-	-	6.80	3.40	3.40
S	S	344	R	29.00	0.01	26.0	9.35	-	-	6.80	3.70	3.10
S	S	1-269	L	36.50	1.00	20.2	7.38	-	-	7.48	3.25	4.23
S	S	334	R	53.00	0.00	29.0	9.33	-	-	7.20	4.05	3.15
S	S	230N	L	DEAD	-	-	-	-	-	-	-	-
S	S	233N	L	16.00	2.00	-	-	-	-	-	-	-
S	S	234N	L	DEAD	-	-	-	-	-	-	-	-
S	S	237N	L	DEAD	-	-	-	-	-	-	-	-
S	S	39N	L	14.50	0.50	-	-	-	-	-	-	-
S	S	45N	L	DEAD	-	-	-	-	-	-	-	-
S	S	46N	L	DEAD	-	-	-	-	-	-	-	-
S	S	229N	L	DEAD	-	-	-	-	-	-	-	-
S	S	53N	L	DEAD	-	-	-	-	-	-	-	-
S	S	226N	L	17.25	9.00	-	-	-	-	-	-	-
S	S	231N	L	19.50	7.00	-	-	-	-	-	-	-
S	S	235N	L	DEAD	-	-	-	-	-	-	-	-
S	S	84-32	K	12.50	18.50	31.0	9.03	14.83	27.30	5.35	2.48	2.87
S	S	84-18	K	12.50	28.00	19.5	6.19	10.32	21.85	8.70	2.30	6.40
S	S	185	K	10.50	4.50	24.5	7.23	11.98	15.00	8.55	2.73	5.82
S	S	214	K	-	-	-	-	-	-	DEAD	-	-
S	S	49	K	14.75	0.50	30.2	9.16	17.30	14.05	7.95	3.10	4.85
S	S	217	K	13.25	18.50	22.5	6.97	11.75	16.50	9.80	2.30	7.50
S	S	204	K	16.50	1.50	26.0	7.48	9.81	17.75	8.70	2.65	6.05
S	S	6	K	13.75	11.50	28.0	8.52	15.80	28.90	8.35	2.73	5.62
S	S	145	K	13.50	0.50	23.5	6.71	10.21	25.25	9.00	2.58	6.42
S	S	201	D	DEAD	-	-	-	-	-	DEAD	-	-
S	S	184	B	14.25	18.50	22.5	6.71	10.20	17.85	9.00	2.30	6.70
S	S	104	D	16.00	0.50	29.7	8.77	15.51	23.40	7.85	2.58	5.27
S	S	39	D	19.25	0.50	26.5	8.00	11.55	15.45	7.90	2.25	5.65
S	S	193	D	21.25	0.50	27.5	8.52	11.56	17.35	7.85	1.85	6.00
S	S	107	D	19.25	3.50	26.5	8.52	13.83	18.25	7.00	2.30	4.70
S	S	110	D	17.25	2.50	25.0	7.74	11.79	14.85	8.05	2.30	5.75
S	S	146	D	16.75	8.50	29.0	8.77	13.18	14.25	7.85	2.73	5.12
S	S	140	D	20.00	2.00	28.5	8.77	13.76	16.25	8.80	2.53	6.27
S	S	121	D	19.50	5.50	24.0	6.71	11.31	20.50	8.13	2.00	6.13
S	S	125	D	24.00	1.50	27.0	8.26	12.00	22.05	8.18	2.40	5.78
S	S	84-15	K	9.00	11.00	13.0	3.35	8.33	16.55	9.80	2.13	7.67
S	S	210	K	DEAD	-	-	-	-	-	DEAD	-	-
S	S	215	K	11.00	5.00	22.5	6.71	10.46	13.70	8.70	3.18	5.52
S	S	192	K	12.75	24.00	25.0	6.58	13.70	16.75	8.80	2.90	5.90
S	S	216	K	12.50	5.00	22.0	6.45	10.58	22.85	8.75	1.85	6.90
S	S	213	K	-	-	-	-	-	-	DEAD	-	-
S	S	183	K	12.00	13.50	23.5	6.97	10.84	14.30	8.33	3.10	5.23
S	S	194	K	13.25	1.50	32.5	9.29	13.43	11.55	7.85	3.18	4.67
S	S	202	K	16.00	3.50	28.5	8.65	12.87	22.50	7.30	3.45	3.85
S	S	117	K	16.75	3.00	24.0	7.23	11.35	22.05	7.70	2.48	5.22
S	S	111	D	14.75	15.00	24.0	6.97	11.27	12.25	9.60	2.40	7.20
S	S	15	B	16.75	9.00	21.0	6.06	9.03	20.50	7.50	2.05	5.45
S	S	127	D	13.00	59.50	DEAD	-	-	-	DEAD	-	-
S	S	122	D	20.00	0.50	30.5	8.77	12.03	20.00	7.70	2.73	4.97
S	S	144	D	18.00	19.00	32.0	9.55	12.68	23.00	7.70	3.30	4.40
S	S	137	D	15.75	8.50	19.0	5.68	9.82	13.00	8.13	2.40	5.73
S	S	105	D	24.50	0.50	28.5	8.26	12.58	23.00	7.58	3.05	4.53
S	S	130	D	19.75	0.00	28.5	7.74	12.57	18.50	9.80	2.65	7.15
S	S	115	D	19.25	7.50	23.0	6.97	10.26	13.90	8.13	2.25	5.88
S	S	101	D	19.00	0.00	22.0	6.19	9.90	19.20	8.95	2.53	6.42
S	S	3	D	28.75	0.50	-	-	-	-	-	-	-
S	S	4	D	29.25	0.50	-	-	-	-	-	-	-
S	S	5	D	21.25	2.50	-	-	-	-	-	-	-
S	S	7	D	19.50	2.50	-	-	-	-	-	-	-
S	S	8	D	20.00	3.00	-	-	-	-	-	-	-
S	S	9	D	18.00	1.00	-	-	-	-	-	-	-
S	S	12	B	13.25	0.13	-	-	-	-	-	-	-
S	S	15	K	23.50	0.50	-	-	-	-	-	-	-
S	S	16	D	16.00	0.50	-	-	-	-	-	-	-
S	S	18	D	DEAD	-	-	-	-	-	-	-	-
S	S	19	K	28.00	0.50	-	-	-	-	-	-	-
S	S	20	D	14.25	0.50	-	-	-	-	-	-	-
S	S	22	K	17.50	0.50	-	-	-	-	-	-	-
S	S	23	D	18.25	4.00	-	-	-	-	-	-	-
S	S	24	K	16.50	1.00	-	-	-	-	-	-	-
S	S	25	K	9.50	0.50	-	-	-	-	-	-	-
S	S	42	K	14.50	1.50	-	-	-	-	-	-	-
S	S	48	D	27.00	0.03	-	-	-	-	-	-	-

APPENDIX 3

DATA FOR MID-OCTOBER 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)
S	S	25	L	23.00	0.00
S	S	17	L	DEAD	-
S	S	11	L	19.75	0.00
S	S	16	L	18.25	0.50
S	S	6	L	27.75	0.00
S	S	84-08	E	28.25	0.00
S	S	1-261	E	30.50	0.00
S	S	81-64	E	DEAD	-
S	S	81-68	E	28.00	0.50
S	S	82-27	E	27.50	0.50
S	S	81-71	E	28.25	0.00
S	S	82-23	E	26.25	0.50
S	S	82-33	E	33.50	0.00
S	S	81-58	E	29.25	0.00
S	S	84-10	E	25.75	0.00
S	S	82-26	E	DEAD	-
S	S	284	R	30.50	0.00
S	S	329	R	35.50	0.00
S	S	307	R	DEAD	-
S	S	84-09	R	DEAD	-
S	S	84-11	R	42.50	0.00
R	S	23	L	21.50	0.50
R	S	7	L	18.00	6.00
R	S	14	L	21.00	0.00
R	S	30	L	20.00	0.50
R	S	22	L	26.50	0.00
R	S	1-266	E	28.25	0.00
R	S	82-34	E	24.75	2.50
R	S	82-14	E	28.00	0.50
R	S	81-54	E	25.00	3.50
R	S	81-52	E	DEAD	-
R	S	81-72	E	25.00	0.03
R	S	81-73	E	29.00	0.50
R	S	1-267	E	28.50	0.04
R	S	81-59	E	DEAD	-
R	S	81-55	E	26.25	2.00
R	S	81-51	E	28.50	0.00
R	S	273	R	35.50	0.50
R	S	81-03	R	30.00	30.00
R	S	344	R	31.00	0.05
R	S	1-269	R	38.50	1.50
R	S	334	R	54.00	0.00
S	G	84-32	K	13.00	6.50
S	G	84-18	K	12.00	1.50
S	G	185	K	11.00	4.00
S	G	214	K	DEAD	-
S	G	49	K	16.00	0.50
S	G	217	K	14.00	8.50
S	G	204	K	17.75	0.50
S	G	6	K	15.00	3.50
S	G	145	K	14.00	6.00
S	G	201	K	DEAD	-
S	G	184	D	14.50	12.00
S	G	104	D	16.75	1.00
S	G	39	D	20.00	0.50
S	G	193	B	22.00	0.00
S	G	107	D	20.00	1.50
S	G	110	D	18.00	0.00
S	G	146	D	16.75	3.50
S	G	140	D	24.00	0.09
S	G	121	D	21.00	5.00
S	G	125	D	25.00	5.00
R	G	84-15	K	9.00	2.00
R	G	210	K	DEAD	-
R	G	215	K	12.25	11.00
R	G	192	K	12.75	5.00
R	G	216	K	12.50	0.50
R	G	213	K	DEAD	-
R	G	183	K	12.50	5.00
R	G	194	K	14.75	3.00
R	G	202	K	16.50	3.50
R	G	117	K	17.50	2.00
R	G	111	D	15.50	18.50
R	G	15	B	17.50	12.00
R	G	127	D	DEAD	-
R	G	122	B	21.75	0.00
R	G	144	D	19.00	0.50
R	G	137	D	16.50	8.50
R	G	105	D	26.75	0.00
R	G	130	D	21.00	3.00
R	G	115	D	22.25	1.00
R	G	101	D	20.00	4.50

APPENDIX 3

DATA FOR THE END OF OCTOBER 1985

GROUP	TYPE	NUMBER	AGE - SEX	WEIGHT (Kg)	FAECAL EPG (x100)	PCV %	Hb G%	RBC (M)	WBC (K)	TOTAL PROT. (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
S	S	25	L	23.75	0.00	27.5	8.92	8.95	9.00	7.20	3.10	4.10
S	S	17	L	DEAD	-	-	-	-	-	DEAD	-	-
S	S	11	L	20.50	0.00	31.8	9.44	9.54	6.55	7.35	3.70	3.65
S	S	16	L	19.00	0.01	26.5	8.39	8.37	8.35	6.53	2.75	3.78
S	S	6	L	29.50	0.00	28.8	8.92	8.27	10.45	6.93	4.50	2.43
S	S	84-08	E	29.50	0.03	32.8	11.02	8.92	8.75	8.05	4.20	3.85
S	S	1-261	E	31.50	1.50	24.8	7.87	8.17	10.25	8.60	3.88	4.72
S	S	81-64	E	DEAD	-	-	-	-	-	DEAD	-	-
S	S	81-68	E	27.75	0.00	36.3	12.07	8.83	8.50	9.80	4.50	5.30
S	S	82-27	E	27.00	0.50	26.8	8.29	8.38	16.85	8.05	3.70	4.35
S	S	81-71	E	29.00	0.00	25.5	7.61	7.42	10.70	8.90	3.40	5.50
S	S	82-23	E	25.00	2.50	26.8	9.18	8.49	11.40	7.35	3.40	3.95
S	S	82-33	E	30.00	0.00	33.3	9.97	9.43	14.85	7.08	3.55	3.53
S	S	81-58	E	24.50	0.04	34.8	10.54	8.40	19.10	8.33	3.45	4.88
S	S	84-10	E	24.75	0.50	26.0	8.13	8.84	11.05	8.33	3.30	5.03
S	S	82-26	E	DEAD	-	-	-	-	-	DEAD	-	-
S	S	284	R	30.50	2.50	25.3	7.76	8.41	9.05	8.33	2.93	5.40
S	S	329	R	36.50	0.50	29.5	9.18	8.61	9.05	7.50	4.20	3.30
S	S	307	R	CULLED	-	-	-	-	-	DEAD	-	-
S	S	84-09	R	DEAD	-	-	-	-	-	DEAD	-	-
S	S	84-11	R	44.50	2.00	26.5	8.13	8.54	9.45	7.20	4.35	2.85
R	S	23	L	22.75	0.00	21.0	8.27	8.06	12.00	6.80	3.10	3.70
R	S	7	L	19.00	2.50	22.0	7.47	7.85	9.10	5.55	3.45	2.10
R	S	14	L	22.50	0.00	29.3	10.93	8.56	10.75	DEAD	-	-
R	S	30	L	23.00	0.00	32.0	9.33	8.12	10.45	7.08	3.88	3.20
R	S	22	L	28.50	0.00	29.3	8.00	8.44	13.45	7.20	3.10	4.10
R	S	1-266	E	30.50	0.04	31.8	9.60	10.38	8.80	7.08	4.35	2.73
R	S	82-34	E	24.25	1.00	20.5	7.20	5.81	10.65	6.93	3.55	3.38
R	S	82-14	E	24.25	4.50	23.0	7.20	7.37	13.70	7.20	2.45	4.75
R	S	81-54	E	24.50	4.00	19.0	5.87	4.42	11.30	7.35	2.75	4.60
R	S	81-52	E	DEAD	-	-	-	-	-	DEAD	-	-
R	S	81-72	E	24.50	0.50	15.8	3.73	4.00	12.75	4.85	1.63	3.22
R	S	81-73	E	31.00	1.00	28.8	9.33	8.19	10.30	8.05	3.55	4.50
R	S	1-267	E	29.50	0.50	36.0	8.53	7.18	11.35	9.90	3.25	6.65
R	S	81-59	E	DEAD	-	-	-	-	-	DEAD	-	-
R	S	81-55	E	26.00	1.00	26.3	7.47	5.97	12.75	8.18	3.25	4.93
R	S	81-51	E	28.00	0.03	20.3	6.93	7.07	12.75	6.65	4.05	2.60
R	S	273	R	33.75	2.00	23.5	8.00	5.15	10.75	8.60	4.20	4.40
R	S	81-03	R	31.00	0.50	25.8	9.07	4.90	10.95	7.08	2.75	4.33
R	S	344	R	32.00	1.00	24.8	9.60	7.95	12.85	7.08	3.40	3.68
R	S	1-269	R	40.00	2.50	28.3	11.20	7.31	15.55	7.08	3.25	3.83
R	S	334	R	53.50	0.01	30.3	10.67	9.36	8.65	8.60	3.88	4.72
T	S	230N	E	DEAD	-	-	-	-	-	-	-	-
T	S	233N	E	16.50	35.50	-	-	-	-	-	-	-
T	S	234N	E	DEAD	-	-	-	-	-	-	-	-
T	S	237N	E	DEAD	-	-	-	-	-	-	-	-
T	S	39N	L	15.75	0.50	-	-	-	-	-	-	-
T	S	45N	E	DEAD	-	-	-	-	-	-	-	-
T	S	46N	E	DEAD	-	-	-	-	-	-	-	-
T	S	229N	E	DEAD	-	-	-	-	-	-	-	-
T	S	53N	E	DEAD	-	-	-	-	-	-	-	-
T	S	226N	L	17.50	8.50	-	-	-	-	-	-	-
T	S	231N	R	18.25	6.00	-	-	-	-	-	-	-
T	S	235N	L	DEAD	-	-	-	-	-	-	-	-
S	G	84-32	K	13.00	2.00	27.5	10.13	-	-	8.33	2.65	5.68
S	G	84-18	K	12.00	N.A.	22.0	6.40	-	-	7.63	2.40	5.23
S	G	185	K	10.00	1.50	26.3	7.73	-	-	8.60	2.65	5.95
S	G	214	K	DEAD	-	-	-	-	-	DEAD	-	-
S	G	49	K	15.75	1.00	27.0	9.33	-	-	7.63	3.45	4.18
S	G	217	K	14.50	1.00	30.0	10.13	-	-	9.30	3.18	6.12
S	G	204	K	17.50	3.50	25.5	9.07	-	-	7.90	2.73	5.17
S	G	6	K	14.50	3.50	30.5	5.07	-	-	8.33	2.78	5.55
S	G	145	K	14.75	N.A.	N.A.	4.43	-	-	8.18	3.45	4.73
S	G	201	K	DEAD	-	-	-	-	-	DEAD	-	-
S	G	184	D	14.00	1.00	27.5	7.20	-	-	8.75	2.00	6.75
S	G	104	D	17.00	0.00	23.5	5.07	-	-	7.20	2.65	4.55
S	G	39	D	21.50	0.00	30.0	9.26	-	-	5.95	2.85	3.10
S	G	193	B	22.00	0.50	27.0	8.80	-	-	7.35	2.65	4.70
S	G	107	D	21.00	3.50	29.0	9.33	-	-	7.48	2.53	4.95
S	G	110	D	19.00	0.12	26.5	6.88	-	-	8.60	2.90	5.70
S	G	146	D	16.50	10.00	26.0	8.00	-	-	8.18	2.78	5.40
S	G	140	D	24.50	0.50	35.0	10.51	-	-	8.33	2.65	5.68
S	G	121	D	22.25	3.50	28.0	7.57	-	-	10.30	1.45	8.85
S	G	125	D	25.50	2.00	25.0	7.47	-	-	7.63	2.40	5.33
R	G	84-15	K	8.00	13.00	8.0	1.55	-	-	8.60	1.60	7.00
R	G	210	K	DEAD	-	-	-	-	-	DEAD	-	-
R	G	215	K	12.00	15.00	22.0	6.67	-	-	10.90	2.40	8.50
R	G	192	K	12.50	7.00	22.0	6.40	-	-	8.33	2.90	5.43
R	G	216	K	12.50	0.00	25.5	7.47	-	-	10.30	2.40	7.90
R	G	213	K	DEAD	-	-	-	-	-	DEAD	-	-
R	G	183	K	12.00	9.50	25.0	7.47	-	-	8.60	1.85	6.75
R	G	194	K	14.00	4.00	26.5	8.00	-	-	7.90	1.60	6.30
R	G	202	K	15.75	4.00	29.0	6.40	-	-	8.90	2.73	6.17
R	G	117	K	16.75	5.50	23.8	7.04	-	-	8.33	2.00	6.33
R	G	111	D	15.00	28.00	21.0	6.40	-	-	9.03	2.40	6.63
R	G	15	B	17.00	15.50	17.0	4.80	-	-	7.63	1.85	5.78
R	G	127	D	DEAD	-	-	-	-	-	DEAD	-	-
R	G	122	B	21.25	0.00	30.0	9.07	-	-	8.05	2.53	5.52
R	G	144	D	17.50	1.00	28.0	8.27	-	-	6.93	2.65	4.28
R	G	137	D	15.50	2.00	18.5	5.33	-	-	7.85	2.40	5.47
R	G	105	D	26.50	0.50	28.5	8.00	-	-	9.50	3.18	6.32
R	G	130	D	22.25	0.50	31.5	9.07	-	-	9.30	2.58	6.72
R	G	115	D	21.75	0.50	26.0	7.73	-	-	8.33	2.40	5.93
R	G	101	D	19.50	1.00	21.5	7.04	-	-	8.90	2.20	6.70
T	G	3	D	26.75	6.00	-	-	-	-	-	-	-
T	G	4	D	29.50	1.50	-	-	-	-	-	-	-
T	G	5	D	20.50	3.50	-	-	-	-	-	-	-
T	G	7	D	22.50	1.50	-	-	-	-	-	-	-
T	G	8	D	20.25	1.00	-	-	-	-	-	-	-
T	G	9	B	17.75	2.00	-	-	-	-	-	-	-
T	G	12	K	14.50	1.50	-	-	-	-	-	-	-
T	G	15	D	22.25	0.50	-	-	-	-	-	-	-
T	G	16	D	16.75	2.50	-	-	-	-	-	-	-
T	G	18	D	DEAD	-	-	-	-	-	-	-	-
T	G	19	D	28.25	0.50	-	-	-	-	-	-	-
T	G	20	K	15.75	1.00	-	-	-	-	-	-	-
T	G	22	K	17.00	6.00	-	-	-	-	-	-	-
T	G	23	D	19.00	5.00	-	-	-	-	-	-	-
T	G	24	K	18.00	21.50	-	-	-	-	-	-	-
T	G	25	K	10.25	1.00	-	-	-	-	-	-	-
T	G	42	K	14.50	1.00	-	-	-	-	-	-	-
T	G	48	D	27.25	0.00	-	-	-	-	-	-	-

APPENDIX 4

M.C.V. DATA FROM EXPERIMENTAL ANIMALS AT MANKON - 1984-85

GROUP	DATE		LAMBS	EWES	RAMS	KIDS	DOES	BUCKS
STD	Nov 84	Mean	31.85	35.21	28.46	22.81	23.75	24.04
	3.5	s.d.	5.69	4.11	2.59			
STD	Mar 85	Mean	31.15	32.06	27.77	17.36	18.01	23.87
		s.d.	3.28	2.11	1.98	1.34	1.59	
STD	Jul 85	Mean	29.75	32.01	30.10	20.98	19.58	21.02
		s.d.	3.05	3.75	3.02	3.30	2.34	
STD	Oct 85	Mean	32.61	34.66	31.77	20.52	21.22	23.79
		s.d.	1.78	4.40	2.21	3.02	1.35	
RED	Nov 84	Mean	28.81	33.59	33.89	23.64	26.11	22.41
		s.d.	2.98	3.13	12.38	4.55	2.99	0.21
RED	Mar 85	Mean	29.15	32.30	28.37	19.38	19.88	19.64
		s.d.	2.71	4.51	3.26	1.47	2.04	3.13
RED	Jul 85	Mean	35.12	30.96	27.91	19.32	20.95	21.69
		s.d.	5.45	4.96	2.89	1.77	3.97	3.39
RED	Oct 85	Mean	32.46	37.48	40.06	20.67	22.27	24.31
		s.d.	5.40	7.17	9.06	2.62	1.76	1.48

M.C.H. DATA FROM EXPERIMENTAL ANIMALS AT MANKON - 1984-85

GROUP	DATE		LAMBS	EWES	RAMS	KIDS	DOES	BUCKS
STD	Mar 85	Mean	10.67	10.62	9.15	5.56	6.12	7.57
		s.d.	1.11	0.68	1.19	0.55	0.47	
STD	Jul 85	Mean	11.46	12.33	12.10	6.59	7.12	6.85
		s.d.	1.24	2.34	1.42	0.73	0.61	
STD	Oct 85	Mean	10.17	10.99	9.80	6.12	6.41	7.37
		s.d.	0.42	1.52	0.76	0.73	0.43	
RED	Mar 85	Mean	9.90	11.07	9.78	6.59	6.67	6.49
		s.d.	0.83	1.54	1.08	0.52	0.72	0.71
RED	Jul 85	Mean	12.30	11.35	10.26	6.73	8.00	7.45
		s.d.	1.80	2.10	1.22	1.41	2.05	1.38
RED	Oct 85	Mean	10.70	11.07	14.57	5.97	6.47	7.80
		s.d.	1.41	1.55	2.88	1.02	0.57	0.41

M.C.H.C. DATA FROM EXPERIMENTAL ANIMALS AT MANKON - 1984-85

GROUP	DATE		LAMBS	EWES	RAMS	KIDS	DOES	BUCKS
STD	Mar 85	Mean	34.28	33.80	32.85	32.02	34.06	31.73
		s.d.	1.11	1.48	2.03	2.11	2.01	
STD	Jul 85	Mean	38.65	33.47	40.43	31.75	36.78	32.60
		s.d.	4.42	5.13	6.20	3.38	4.79	
STD	Oct 85	Mean	31.22	31.72	30.84	29.92	30.24	30.98
		s.d.	1.15	1.67	0.24	1.12	1.15	
RED	Mar 85	Mean	33.97	34.34	34.51	34.01	33.56	33.16
		s.d.	0.94	1.98	1.39	1.62	1.43	1.63
RED	Jul 85	Mean	35.14	36.60	36.76	34.69	37.88	34.26
		s.d.	2.59	1.87	2.84	3.44	3.76	0.99
RED	Oct 85	Mean	33.44	30.01	36.59	28.74	29.05	28.81
		s.d.	5.16	4.10	2.47	1.76	1.10	0.08

APPENDIX 5

DATA FOR MID-NOVEMBER 1985

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	7.00	-
2	S	155	L	9.00	-
2	S	157	L	9.25	-
2	S	112	L	11.25	-
2	S	154	L	11.50	-
2	S	788	L	13.50	-
2	S	291	Y	15.50	-
2	S	183	Y	16.75	-
2	S	325	Y	19.25	-
2	S	141	Y	20.50	-
2	S	81-58	E	22.25	-
2	S	84-10	E	23.50	-
2	S	82-23	E	24.50	-
2	S	1-261	E	24.75	-
2	S	82-27	E	26.00	-
2	S	81-68	E	27.25	-
2	S	755	R	19.75	-
2	S	761	R	29.75	-
2	S	284	R	31.00	-
2	S	329	R	36.50	-
4	S	165	L	6.50	-
4	S	161	L	8.50	-
4	S	167	L	9.50	-
4	S	168	L	10.00	-
4	S	106	L	11.50	-
4	S	104	L	13.50	-
4	S	764	Y	15.50	-
4	S	144	Y	16.75	-
4	S	219	Y	18.25	-
4	S	142	Y	19.00	-
4	S	82-14	E	23.50	-
4	S	81-54	E	24.00	-
4	S	81-50	E	24.25	-
4	S	82-33	E	25.00	-
4	S	81-55	E	26.25	-
4	S	81-51	E	26.75	-
4	S	341	R	22.50	-
4	S	81-37	R	30.50	-
4	S	344	R	31.00	-
4	S	81-03	R	35.00	-
T	S	100	L	11.25	1.00
T	S	39	E	15.75	0.50
T	S	81-12	E	N.A.	-
T	S	81-24	E	N.A.	-
T	S	55	L	N.A.	-
T	S	231	R	18.25	6.00
T	S	322	E	N.A.	-
T	S	335	E	N.A.	-
T	S	221	L	N.A.	-
T	S	81-41	E	N.A.	-
T	S	81-57	E	N.A.	-
T	S	300	E	N.A.	-
T	G	3	D	26.75	6.00
T	G	4	D	29.50	1.50
T	G	5	D	20.50	3.50
T	G	8	D	20.25	1.00
T	G	FEM	Y	18.50	0.50
T	G	6-12	K	12.25	2.50
T	G	BM2-5	K	8.50	0.00
T	G	1F2-5	K	N.A.	-
T	G	2F2-5	K	N.A.	-
T	G	20F	Y	15.75	1.00
T	G	7	D	22.50	1.50
T	G	16	D	16.75	2.50
T	G	42	Y	14.50	1.00
T	G	49	D	22.25	0.50
T	G	BM2	K	N.A.	-
M	S	792	E	14.25	-
M	S	230	E	15.00	-
M	S	108	E	16.00	-
M	S	702	E	17.00	-
M	S	110	E	17.25	-
M	S	712	E	16.50	-
M	S	790	E	17.50	-
M	S	779	E	21.75	-
M	S	753	E	22.50	-
M	S	770	R	25.00	-
M	G	184	D	13.25	-
M	G	118	D	13.75	-
M	G	18	D	14.75	-
M	G	133	D	14.75	-
M	G	70	D	15.50	-
M	G	20	D	15.50	-
M	G	245	D	16.25	-
M	G	242	D	16.25	-
M	G	104	D	16.25	-
M	G	81	B	12.25	-
R	S	787	E	16.25	-
R	S	797	E	19.50	-
R	S	789	E	22.25	-
R	S	81-59	E	22.50	-
R	S	282	E	24.25	-
R	S	274	E	30.00	-
R	G	265	D	13.00	-
R	G	53	D	14.50	-
R	G	117	D	16.50	-
R	G	27	D	17.75	-
R	G	293	D	18.00	-
R	G	30	D	19.00	-

APPENDIX 5

DATA FOR THE END OF NOVEMBER 1985

EXP - GRP	TYPE	ANIMAL - NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (×100)
2	S	307	L	7.50	52.00
2	S	155	L	11.00	5.50
2	S	157	L	11.00	2.00
2	S	112	L	11.75	6.00
2	S	154	L	14.25	2.50
2	S	788	L	14.25	22.00
2	S	291	Y	18.00	3.50
2	S	183	Y	19.50	0.00
2	S	325	Y	20.25	0.03
2	S	141	Y	21.25	0.00
2	S	81-58	E	19.50	13.50
2	S	84-10	E	23.75	2.00
2	S	82-23	E	23.50	2.00
2	S	1-261	E	23.00	1.50
2	S	82-27	E	26.50	0.50
2	S	81-68	E	29.00	0.00
2	S	755	R	20.75	0.50
2	S	761	R	30.75	2.00
2	S	284	R	31.50	8.50
2	S	329	R	37.50	0.00
4	S	165	L	7.25	1.50
4	S	161	L	10.25	1.50
4	S	167	L	11.25	2.00
4	S	168	L	10.75	1.00
4	S	106	L	11.00	1.80
4	S	104	L	15.00	1.00
4	S	764	Y	18.50	3.50
4	S	144	Y	17.00	0.50
4	S	219	Y	19.00	0.50
4	S	142	Y	19.25	0.50
4	S	82-14	E	23.00	1.00
4	S	81-54	E	23.50	8.50
4	S	81-50	E	23.50	4.00
4	S	82-33	E	25.00	0.05
4	S	81-55	E	24.75	0.00
4	S	81-51	E	23.00	0.04
4	S	341	R	22.50	5.00
4	S	81-37	R	34.50	1.00
4	S	344	R	30.25	0.01
4	S	81-03	R	30.25	2.00
2	G	616	K	7.25	0.50
2	G	622	K	7.75	22.00
2	G	609	K	9.00	3.50
2	G	607	K	9.75	10.50
2	G	11	Y	11.00	1.50
2	G	26	Y	10.00	2.50
2	G	119	Y	12.75	1.00
2	G	7	Y	11.75	0.17
2	G	22	Y	13.50	4.50
2	G	204	D	17.50	1.00
2	G	228	D	16.00	15.50
2	G	49	D	15.50	0.13
2	G	146	D	14.75	6.00
2	G	238	D	14.75	0.50
2	G	145	D	14.00	3.50
2	G	6	D	14.25	1.50
2	G	64	D	16.50	0.00
2	G	217	B	14.00	4.00
2	G	84-18	B	12.00	3.50
2	G	82	B	11.75	7.00
4	G	90	K	9.75	18.50
4	G	606	K	8.00	-
4	G	630	K	9.00	-
4	G	608	K	9.50	-
4	G	8	Y	11.00	0.50
4	G	183	Y	10.25	0.50
4	G	240	Y	12.75	1.50
4	G	284	Y	11.50	1.50
4	G	192	Y	12.00	0.50
4	G	144	D	18.00	0.04
4	G	202	D	16.50	0.50
4	G	137	D	15.25	0.50
4	G	149	D	15.00	0.00
4	G	292	D	14.75	0.50
4	G	220	D	14.00	0.50
4	G	111	D	14.75	3.00
4	G	31	D	16.75	0.00
4	G	15	B	16.00	2.00
4	G	216	B	12.75	0.00
4	G	215	B	11.25	1.50
T	S	100	L	11.75	3.00
T	S	39	E	15.75	0.00
T	S	81-12	E	15.25	18.00
T	S	81-24	E	16.25	2.00
T	S	55	L	11.50	12.00
T	S	231	R	17.25	21.50
T	S	322	E	16.25	1.50
T	S	335	E	24.25	6.00
T	S	221	L	13.25	13.50
T	S	81-41	E	17.25	N.A
T	S	81-57	E	14.00	14.00
T	S	300	E	20.00	38.00
T	G	3	D	27.75	1.00
T	G	4	D	26.75	0.50
T	G	5	D	20.75	1.50
T	G	8	D	20.00	5.00
T	G	FEM	Y	18.00	6.00
T	G	6-12	K	12.50	1.50
T	G	BM2-5	K	13.00	1.50
T	G	1F2-5	K	-	-
T	G	2F2-5	K	-	-
T	G	20F	Y	15.00	2.50
T	G	7	D	18.50	4.50
T	G	16	D	16.50	0.12
T	G	42	Y	14.50	3.00
T	G	49	D	21.50	2.50
T	G	BM2	K	15.00	2.50
M	S	792	E	14.00	5.50
M	S	230	E	15.50	6.00
M	S	108	E	15.00	3.00
M	S	702	E	18.75	5.00
M	S	110	E	17.75	3.00
M	S	712	E	16.00	4.50
M	S	790	E	17.50	15.50
M	S	779	E	23.50	2.00
M	S	753	E	21.50	5.50
M	S	770	R	26.00	6.00
M	G	184	D	14.00	5.00
M	G	118	D	14.25	1.50
M	G	18	D	16.00	12.50
M	G	133	D	14.00	15.00
M	G	70	D	16.50	0.50
M	G	20	D	16.75	0.04
M	G	245	D	17.25	0.50
M	G	242	D	17.00	1.00
M	G	104	D	16.75	4.50
M	G	81	B	12.75	2.00
R	S	787	E	17.00	2.00
R	S	797	E	19.25	12.00
R	S	789	E	22.50	1.50
R	S	81-59	E	19.50	3.50
R	S	282	E	24.25	0.00
R	S	274	E	30.00	0.00
R	G	265	D	13.00	0.00
R	G	53	D	15.75	1.00
R	G	117	D	17.25	4.00
R	G	27	D	18.25	4.00
R	G	293	D	17.25	0.50
R	G	30	D	19.00	0.17

APPENDIX 5

DATA FOR THE BEGINNING OF DECEMBER 1985

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)	PCV %	TOTAL PROTEIN (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
2	S	307	L	0.00	29.5	6.40	3.80	2.60
2	S	155	L	13.50	27.5	6.93	3.95	2.98
2	S	157	L	3.50	31.3	6.93	4.10	2.83
2	S	112	L	6.00	17.5	7.08	3.15	3.93
2	S	154	L	0.50	29.3	6.93	4.50	2.43
2	S	788	L	28.50	18.3	6.65	3.15	3.50
2	S	291	Y	2.50	22.5	6.80	3.40	3.40
2	S	183	Y	0.00	29.0	6.65	4.05	2.60
2	S	325	Y	0.01	23.8	7.48	3.00	4.48
2	S	141	Y	0.00	30.8	7.75	4.35	3.40
2	S	81-58	E	7.00	11.8	N.A.	-	-
2	S	84-10	E	1.00	27.3	8.60	3.80	4.80
2	S	82-23	E	1.50	31.3	7.48	3.25	4.23
2	S	1-261	E	0.09	24.0	7.48	3.15	4.33
2	S	82-27	E	0.01	31.0	8.33	4.05	4.28
2	S	81-68	E	1.50	37.0	8.75	3.95	4.80
2	S	755	R	0.50	29.0	6.53	3.30	3.23
2	S	761	R	0.50	26.5	8.05	3.40	4.65
2	S	284	R	4.50	22.8	7.20	2.93	4.27
2	S	329	R	0.00	28.8	7.75	3.88	3.87
4	S	165	L	1.00	25.8	7.20	4.30	2.90
4	S	161	L	0.00	25.8	6.53	3.65	2.88
4	S	167	L	0.12	24.5	6.53	4.05	2.48
4	S	168	L	0.50	31.0	8.33	4.30	4.03
4	S	106	L	11.50	23.5	8.33	3.45	4.88
4	S	104	L	0.50	26.3	10.35	3.25	7.10
4	S	764	Y	5.00	26.3	8.33	2.45	5.88
4	S	144	Y	0.50	26.3	7.48	3.65	3.83
4	S	219	Y	0.50	27.5	7.48	4.10	3.38
4	S	142	Y	0.00	22.8	6.53	3.80	2.73
4	S	82-14	E	1.50	21.5	7.63	3.15	4.48
4	S	81-54	E	0.50	21.8	7.48	3.30	4.18
4	S	81-50	E	1.00	22.3	7.48	3.95	3.53
4	S	82-33	E	0.04	30.5	7.35	3.10	4.25
4	S	81-55	E	0.00	20.3	6.65	3.25	3.40
4	S	81-51	E	2.00	20.8	7.90	4.10	3.80
4	S	341	R	0.50	23.3	7.20	3.15	4.05
4	S	81-37	R	0.07	31.3	7.63	4.10	3.53
4	S	344	R	0.00	27.3	7.48	4.10	3.38
4	S	81-03	R	0.05	24.3	6.93	3.88	3.05
2	G	616	K	0.00	31.8	6.53	3.35	3.18
2	G	622	K	0.50	20.8	7.08	2.73	4.35
2	G	609	K	0.00	30.3	8.33	2.73	5.60
2	G	607	K	2.00	22.5	8.05	2.58	5.47
2	G	11	Y	3.50	23.8	9.15	2.58	6.57
2	G	26	Y	12.00	19.5	9.30	2.98	6.32
2	G	119	Y	2.00	18.8	10.30	3.35	6.95
2	G	7	Y	0.25	24.3	8.33	2.85	5.48
2	G	22	Y	1.50	31.5	8.90	2.85	6.05
2	G	204	D	2.00	28.5	8.33	2.98	5.35
2	G	228	D	11.50	16.0	8.75	1.73	7.02
2	G	49	D	2.50	26.5	8.05	2.85	5.20
2	G	146	D	5.00	26.0	10.35	3.35	7.00
2	G	238	D	2.50	23.0	9.15	2.85	6.30
2	G	145	D	0.13	27.3	8.90	2.53	6.37
2	G	6	D	0.00	32.8	8.33	2.73	5.60
2	G	64	D	0.15	27.3	9.30	2.73	6.57
2	G	217	B	2.00	25.8	9.50	3.05	6.45
2	G	84-18	B	2.00	25.0	8.90	2.73	6.17
2	G	82	B	4.50	30.5	9.00	3.05	5.95
4	G	90	K	5.00	-	9.15	2.58	6.57
4	G	606	K	0.00	26.8	7.20	3.05	4.15
4	G	630	K	0.01	27.3	6.65	2.65	4.00
4	G	608	K	0.00	33.0	6.40	2.73	3.67
4	G	8	Y	1.00	19.3	9.15	2.73	6.42
4	G	183	Y	2.50	24.8	9.30	2.30	7.00
4	G	240	Y	0.07	24.0	8.33	2.53	5.80
4	G	284	Y	4.50	26.0	8.90	2.40	6.50
4	G	192	Y	2.00	16.5	7.75	2.05	5.70
4	G	144	D	2.50	24.3	6.80	2.30	4.50
4	G	202	D	0.04	25.5	8.33	2.98	5.35
4	G	137	D	2.00	21.3	8.33	2.25	6.08
4	G	149	D	1.50	28.3	8.35	3.50	4.85
4	G	292	D	2.50	23.0	8.90	3.50	5.40
4	G	220	D	8.00	12.8	10.35	2.48	7.87
4	G	111	D	7.50	16.8	8.60	1.73	6.87
4	G	31	D	0.50	30.5	8.60	2.90	5.70
4	G	15	B	5.00	12.3	8.60	2.98	5.62
4	G	216	B	0.04	24.5	10.35	2.20	8.15
4	G	215	B	8.00	22.3	9.50	2.73	6.77
M	S	792	E	-	21.0	6.80	3.55	3.25
M	S	230	E	-	25.0	6.65	3.88	2.77
M	S	108	E	-	25.3	6.93	4.10	2.83
M	S	702	E	-	31.5	6.93	3.80	3.13
M	S	110	E	-	24.5	6.53	3.80	2.73
M	S	712	E	-	27.3	7.63	3.30	4.33
M	S	790	E	-	22.5	7.90	3.95	3.95
M	S	779	E	-	22.5	7.20	3.88	3.32
M	S	753	E	-	21.5	7.08	3.45	3.63
M	S	770	R	-	25.3	7.50	3.25	4.25
M	G	184	D	-	21.3	9.50	3.10	6.40
M	G	118	D	-	26.3	8.33	3.25	5.08
M	G	18	D	-	18.3	7.63	2.00	5.63
M	G	133	D	-	21.5	8.90	2.00	6.90
M	G	70	D	-	21.3	5.95	2.98	2.97
M	G	20	D	-	23.3	8.90	2.58	6.32
M	G	245	D	-	23.8	8.18	3.18	5.00
M	G	242	D	-	17.8	6.53	2.20	4.33
M	G	104	D	-	28.8	8.05	2.78	5.27
M	G	81	B	-	21.5	7.90	3.18	4.72
R	S	787	E	-	26.5	7.90	3.70	4.20
R	S	797	E	-	21.8	7.35	3.30	4.05
R	S	789	E	-	26.8	7.48	3.25	4.23
R	S	81-59	E	-	27.0	8.33	3.65	4.68
R	S	282	E	-	32.5	6.80	4.20	2.60
R	S	274	E	-	31.3	7.48	4.05	3.43
R	S	265	D	-	28.3	7.90	3.35	4.55
R	G	53	D	-	29.0	10.30	2.73	7.57
R	G	117	D	-	22.0	8.60	2.53	6.07
R	G	27	D	-	21.5	7.20	2.25	4.95
R	G	293	D	-	29.3	8.18	2.65	5.53
R	G	30	D	-	28.5	7.20	2.53	4.67

APPENDIX 5

DATA FOR THE END OF DECEMBER 1985

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	10.00	1.00
2	S	155	L	12.50	12.50
2	S	157	L	12.50	5.00
2	S	112	L	13.75	20.00
2	S	154	L	15.75	4.00
2	S	788	L	15.50	18.00
2	S	291	Y	14.25	2.00
2	S	183	Y	20.00	0.50
2	S	325	Y	22.75	0.50
2	S	141	Y	22.75	0.04
2	S	81-58	E	19.25	35.50
2	S	84-10	E	24.25	4.50
2	S	82-23	E	26.50	1.00
2	S	1-261	E	20.25	0.50
2	S	82-27	E	26.50	0.03
2	S	81-68	E	30.25	2.50
2	S	755	R	22.50	0.18
2	S	761	R	31.75	3.00
2	S	284	R	32.00	7.00
2	S	329	R	38.00	0.50
4	S	165	L	9.00	0.05
4	S	161	L	12.50	2.50
4	S	167	L	13.50	2.50
4	S	168	L	12.50	2.00
4	S	106	L	12.50	19.00
4	S	104	L	16.50	1.00
4	S	764	Y	20.00	7.00
4	S	144	Y	19.75	0.50
4	S	219	Y	16.50	0.50
4	S	142	Y	20.00	2.50
4	S	82-14	E	21.25	2.00
4	S	81-54	E	24.50	2.00
4	S	81-50	E	23.50	0.50
4	S	82-33	E	26.50	0.50
4	S	81-55	E	26.00	0.01
4	S	81-51	E	25.25	0.00
4	S	341	R	22.50	1.50
4	S	81-37	R	37.25	0.50
4	S	344	R	31.50	0.00
4	S	81-03	R	32.50	0.50
2	G	616	K	6.00	0.50
2	G	622	K	7.50	0.50
2	G	609	K	9.00	2.50
2	G	607	K	9.25	0.21
2	G	11	Y	10.75	1.00
2	G	26	Y	10.00	11.50
2	G	119	Y	14.00	4.00
2	G	7	Y	12.00	0.50
2	G	22	Y	13.75	0.50
2	G	204	D	17.00	1.00
2	G	228	D	17.50	3.00
2	G	49	D	13.75	5.00
2	G	146	D	16.00	6.00
2	G	238	D	16.25	2.50
2	G	145	D	16.25	3.00
2	G	6	D	16.75	1.50
2	G	64	D	20.50	0.00
2	G	217	B	14.25	1.50
2	G	84-18	B	13.00	1.00
4	G	82	B	13.25	11.00
4	G	90	K	8.50	4.00
4	G	606	K	8.50	0.01
4	G	630	K	7.75	0.50
4	G	608	K	10.00	1.50
4	G	8	Y	11.25	0.50
4	G	183	Y	8.50	20.00
4	G	240	Y	13.75	0.01
4	G	284	Y	12.75	3.00
4	G	192	Y	13.00	0.17
4	G	144	D	15.75	6.50
4	G	202	D	15.50	1.50
4	G	137	D	16.50	0.00
4	G	149	D	17.25	0.50
4	G	292	D	16.00	2.50
4	G	220	D	13.50	14.00
4	G	111	D	14.50	9.00
4	G	31	D	19.00	0.00
4	G	15	B	16.75	0.21
4	G	216	B	13.00	0.00
4	G	215	B	11.00	4.50
4	G	100	L	13.75	1.00
4	G	39	E	15.50	0.50
4	G	81-12	E	14.75	10.50
4	G	81-24	E	15.75	3.00
4	G	55	L	12.50	4.00
4	G	231	R	17.50	7.00
4	G	322	E	16.25	4.00
4	G	335	E	24.25	0.03
4	G	221	L	15.00	4.00
4	G	81-41	E	DEAD	69.50
4	G	81-57	E	16.00	2.50
4	G	300	E	16.00	70.50
T	G	3	D	28.50	2.50
T	G	4	D	27.25	1.00
T	G	5	D	23.25	N.A.
T	G	8	D	22.25	4.00
T	G	FEM	Y	19.50	0.00
T	G	6-12	K	N.A.	-
T	G	BM2-5	K	N.A.	-
T	G	1F2-5	K	N.A.	-
T	G	2F2-5	K	N.A.	-
T	G	20F	Y	15.50	0.16
T	G	7	D	18.50	7.00
T	G	16	D	18.75	2.00
T	G	42	Y	DEAD	-
T	G	49	O	20.00	0.07
T	G	BM2	K	N.A.	-
T	G	792	E	14.50	21.00
T	G	230	E	16.75	12.00
T	G	108	E	15.25	12.50
T	G	702	E	19.50	27.00
T	G	110	E	18.75	15.00
T	G	712	E	14.50	10.50
T	G	790	E	14.50	0.50
T	G	779	E	19.25	7.00
T	G	753	E	17.25	8.50
T	G	770	E	27.50	5.00
T	G	184	D	13.75	1.00
T	G	118	D	14.75	4.00
T	G	18	D	17.50	6.00
T	G	133	D	13.75	25.50
T	G	70	D	18.25	3.00
T	G	20	D	18.00	2.00
T	G	245	D	18.50	2.50
T	G	242	D	17.00	3.00
T	G	104	D	18.25	1.00
T	G	81	B	12.00	5.00
R	S	787	E	DEAD	-
R	S	797	E	15.75	0.00
R	S	789	E	DEAD	-
R	S	81-59	E	19.75	10.50
R	S	282	E	23.50	99.99
R	S	274	E	27.75	0.33
R	G	265	D	12.00	2.00
R	G	53	D	13.75	0.50
R	G	117	D	13.25	2.50
R	G	27	D	16.75	5.00
R	G	293	D	15.75	1.50
R	G	30	D	15.50	2.00

APPENDIX 5

DATA FOR THE END OF JANUARY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	10.00	5.00
2	S	155	L	11.00	11.00
2	S	157	L	12.00	10.00
2	S	112	L	12.50	5.00
2	S	154	L	15.50	10.50
2	S	788	L	15.50	18.00
2	S	291	Y	14.00	4.50
2	S	183	Y	21.75	4.50
2	S	325	Y	22.00	1.50
2	S	141	Y	22.50	0.01
2	S	81-58	E	DEAD	-
2	S	84-10	E	23.50	9.50
2	S	82-23	E	27.00	2.50
2	S	1-261	E	19.00	0.13
2	S	82-27	E	27.50	2.50
2	S	81-68	E	29.00	4.00
2	S	755	R	20.50	2.00
2	S	761	R	30.25	14.50
2	S	284	R	30.50	6.00
2	S	329	R	38.50	0.50
4	S	165	L	9.50	1.00
4	S	161	L	12.50	1.50
4	S	167	L	14.00	2.00
4	S	168	L	13.00	3.50
4	S	106	L	12.50	12.50
4	S	104	L	16.50	0.50
4	S	764	Y	18.50	4.00
4	S	144	Y	21.00	0.50
4	S	219	Y	13.50	1.50
4	S	142	Y	18.50	1.00
4	S	82-14	E	DEAD	-
4	S	81-54	E	25.25	2.00
4	S	81-50	E	24.00	0.50
4	S	82-33	E	27.50	0.00
4	S	81-55	E	25.50	0.00
4	S	81-51	E	26.00	0.01
4	S	341	R	21.50	0.29
4	S	81-37	R	37.50	0.50
4	S	344	R	32.00	0.00
4	S	81-03	R	34.00	0.50
2	G	616	K	DEAD	-
2	G	622	K	6.25	11.50
2	G	609	K	DEAD	-
2	G	607	K	8.50	6.00
2	G	11	Y	10.00	0.50
2	G	26	Y	9.50	19.50
2	G	119	Y	13.25	1.00
2	G	7	Y	10.50	1.00
2	G	22	Y	13.25	2.50
2	G	204	D	15.75	1.50
2	G	228	D	17.00	22.50
2	G	49	D	12.25	6.00
2	G	146	D	14.00	24.50
2	G	238	D	16.25	1.50
2	G	145	D	15.00	11.00
2	G	6	D	18.00	0.50
2	G	64	D	21.50	8.50
2	G	217	B	13.50	0.50
2	G	84-18	B	12.00	4.00
2	G	82	B	11.25	19.00
4	G	90	K	DEAD	-
4	G	606	K	7.25	2.50
4	G	630	K	7.25	6.50
4	G	608	K	8.25	5.50
4	G	8	Y	11.00	0.00
4	G	183	Y	DEAD	-
4	G	240	Y	13.00	0.50
4	G	284	Y	12.00	6.00
4	G	192	Y	12.00	4.50
4	G	144	D	14.50	4.00
4	G	202	D	15.00	0.00
4	G	137	D	17.00	1.00
4	G	149	D	15.00	0.00
4	G	292	D	16.50	0.04
4	G	220	D	DEAD	-
4	G	111	D	12.25	34.50
4	G	31	D	18.25	3.00
4	G	15	B	15.75	3.50
4	G	216	B	12.25	0.00
4	G	215	B	10.00	2.50
T	S	100	L	15.00	1.50
T	S	39	E	17.00	0.13
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	13.00	5.50
T	S	231	R	17.00	8.50
T	S	322	E	13.75	2.00
T	S	335	E	24.00	0.50
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	16.00	1.00
T	S	300	E	DEAD	-
T	G	3	D	28.00	1.00
T	G	4	D	27.50	0.50
T	G	5	D	23.25	0.03
T	G	8	D	23.25	0.09
T	G	FEM	Y	22.25	0.00
T	G	6-12	K	17.00	0.50
T	G	BM2-5	K	8.50	0.00
T	G	1F2-5	K	9.75	1.00
T	G	2F2-5	K	9.00	-
T	G	20F	Y	16.25	1.50
T	G	7	D	19.00	3.50
T	G	16	D	20.00	0.29
T	G	42	Y	DEAD	-
T	G	49	D	21.00	0.00
T	G	BM2	K	9.00	0.50
K	S	792	E	12.50	13.00
K	S	230	E	15.25	8.00
K	S	108	E	15.25	11.50
K	S	702	E	17.50	20.00
K	S	110	E	17.00	5.50
K	S	712	E	DEAD	-
K	S	790	E	14.00	2.00
K	S	779	E	15.50	8.50
K	S	753	E	16.00	1.50
K	S	770	R	27.00	6.50
K	G	184	D	13.00	0.15
K	G	118	D	14.25	0.17
K	G	18	D	15.00	15.50
K	G	133	D	11.25	29.00
K	G	70	D	17.00	7.50
K	G	20	D	17.00	0.50
K	G	245	D	16.00	3.00
K	G	242	D	15.25	1.00
K	G	104	D	14.25	2.00
K	G	81	B	8.75	3.50
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	20.25	0.50
R	S	274	E	24.25	6.00
R	S	796	E	12.50	0.50
R	S	107	E	15.50	0.20
R	S	117	E	14.25	0.00
R	G	265	D	12.00	2.00
R	G	53	D	12.25	1.50
R	G	117	D	12.50	3.00
R	G	27	D	DEAD	-
R	G	293	D	14.50	1.50
R	G	30	D	16.00	3.50

APPENDIX 5

DATA FOR THE END OF FEBRUARY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	9.50	0.50
2	S	155	L	10.75	6.50
2	S	157	L	11.00	3.50
2	S	112	L	12.50	0.00
2	S	154	L	14.75	5.50
2	S	788	L	14.00	6.00
2	S	291	Y	13.00	0.50
2	S	183	Y	22.50	1.00
2	S	325	Y	22.00	0.50
2	S	141	Y	22.50	0.50
2	S	81-58	E	DEAD	-
2	S	84-10	E	22.75	2.50
2	S	82-23	E	27.75	2.50
2	S	1-261	E	18.50	0.00
2	S	82-27	E	28.75	1.50
2	S	81-68	E	22.50	6.00
2	S	755	R	22.00	0.50
2	S	761	R	29.00	0.50
2	S	284	R	31.50	1.50
2	S	329	R	37.50	2.50
4	S	165	L	10.75	0.00
4	S	161	L	12.75	2.50
4	S	167	L	14.00	1.00
4	S	168	L	13.50	2.00
4	S	106	L	12.50	2.50
4	S	104	L	18.50	0.00
4	S	764	Y	15.50	14.50
4	S	144	Y	22.25	2.00
4	S	219	Y	13.50	1.00
4	S	142	Y	16.50	0.50
4	S	82-14	E	DEAD	-
4	S	81-54	E	26.50	4.00
4	S	81-50	E	24.50	0.00
4	S	82-33	E	28.00	0.01
4	S	81-55	E	29.00	0.50
4	S	81-51	E	24.75	0.00
4	S	341	R	23.25	1.50
4	S	81-37	R	39.00	0.50
4	S	344	R	32.50	0.50
4	S	81-03	R	33.75	1.00
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	6.75	4.50
2	G	11	Y	10.00	0.11
2	G	26	Y	7.25	2.50
2	G	119	Y	9.50	0.01
2	G	7	Y	8.00	0.50
2	G	22	Y	13.50	2.50
2	G	204	D	13.00	0.01
2	G	228	D	14.00	1.00
2	G	49	D	9.50	0.17
2	G	146	D	11.00	8.00
2	G	238	D	13.50	0.01
2	G	145	D	13.50	3.00
2	G	6	D	20.00	0.01
2	G	64	D	15.50	0.05
2	G	217	B	12.75	0.50
2	G	84-18	B	12.50	0.00
2	G	82	B	8.50	5.50
4	G	90	K	DEAD	-
4	G	606	K	5.50	3.00
4	G	630	K	6.25	2.50
4	G	608	K	7.75	0.00
4	G	8	Y	9.00	0.00
4	G	183	Y	DEAD	-
4	G	240	Y	12.00	0.03
4	G	284	Y	12.50	2.50
4	G	192	Y	11.25	4.00
4	G	144	D	12.50	0.50
4	G	202	D	14.50	0.50
4	G	137	D	16.50	1.00
4	G	149	D	15.00	0.00
4	G	292	D	15.00	2.00
4	G	220	D	DEAD	-
4	G	111	D	10.25	4.00
4	G	31	D	15.75	1.00
4	G	15	B	14.00	1.00
4	G	216	B	11.00	1.00
4	G	215	B	9.50	1.00
T	S	100	L	13.25	1.50
T	S	39	E	14.75	1.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	13.00	5.00
T	S	231	R	17.75	2.00
T	S	322	E	14.25	0.50
T	S	335	E	25.00	0.50
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	15.75	2.00
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	24.50	2.50
T	G	5	D	21.00	1.00
T	G	8	D	DEAD	-
T	G	FEM	Y	22.75	0.50
T	G	6-12	K	16.00	2.50
T	G	BM2-5	K	10.50	6.50
T	G	1F2-5	K	11.25	0.00
T	G	2F2-5	K	9.50	0.01
T	G	20F	Y	16.00	1.00
T	G	7	D	18.50	1.50
T	G	16	D	18.00	0.00
T	G	42	Y	DEAD	-
T	G	49	D	20.00	1.00
T	G	BM2	K	10.50	0.50
M	S	792	E	9.50	16.00
M	S	230	E	15.25	2.00
M	S	108	E	13.50	2.50
M	S	702	E	13.25	0.00
M	S	110	E	16.00	1.00
M	S	712	E	DEAD	-
M	S	790	E	13.50	0.50
M	S	779	E	13.50	3.50
M	S	753	E	14.50	2.00
M	S	770	R	23.25	1.00
M	G	184	D	12.25	0.50
M	G	118	D	13.00	0.50
M	G	18	D	13.75	1.50
M	G	133	D	8.75	36.00
M	G	70	D	12.25	6.50
M	G	20	D	15.00	0.50
M	G	245	D	14.00	1.50
M	G	242	D	12.75	3.00
M	G	104	D	13.75	0.50
M	G	81	B	N.A.	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	16.50	1.00
R	S	274	E	20.00	1.00
R	S	796	E	N.A.	-
R	S	107	E	13.50	0.50
R	S	117	E	12.75	0.50
R	G	265	D	16.25	0.50
R	G	53	D	11.75	2.00
R	G	117	D	10.25	2.50
R	G	27	D	DEAD	-
R	G	293	D	12.50	1.00
R	G	30	D	14.00	3.50

APPENDIX 5

DATA FOR THE BEGINNING OF MARCH 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)	PCV %	TOTAL PROTEIN (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
2	S	307	L	-	26.0	6.93	3.88	3.05
2	S	155	L	-	21.0	7.20	3.10	4.10
2	S	157	L	-	30.0	8.33	3.45	4.88
2	S	112	L	-	30.0	8.05	3.10	4.95
2	S	154	L	-	22.5	4.30	3.30	1.00
2	S	788	L	-	20.5	7.90	2.60	5.30
2	S	291	Y	-	24.5	7.48	2.75	4.73
2	S	183	Y	-	21.0	8.05	4.20	3.85
2	S	325	Y	-	23.5	4.98	3.30	1.68
2	S	141	Y	-	31.0	7.90	4.35	3.55
2	S	81-58	E	DEAD	-	-	-	-
2	S	84-10	E	-	19.0	8.18	3.70	4.48
2	S	82-23	E	-	27.0	7.95	3.80	4.15
2	S	1-261	E	-	21.0	8.18	3.25	4.93
2	S	82-27	E	-	24.5	7.20	3.88	3.32
2	S	81-68	E	-	29.0	8.33	4.05	4.28
2	S	755	R	-	27.0	7.63	3.45	4.18
2	S	761	R	-	27.5	8.33	3.55	4.78
2	S	284	R	-	26.5	8.05	3.25	4.80
2	S	329	R	-	28.0	7.08	4.30	2.78
4	S	165	L	1.50	30.5	7.48	3.80	3.68
4	S	161	L	1.00	27.5	6.65	3.80	2.85
4	S	167	L	1.50	25.5	2.55	3.65	3.70
4	S	168	L	1.50	26.0	8.05	3.45	4.60
4	S	106	L	3.00	24.5	6.53	3.10	3.43
4	S	104	L	0.04	18.0	7.35	3.65	3.70
4	S	764	Y	9.00	18.0	8.05	2.85	5.20
4	S	144	Y	1.50	30.0	7.20	4.05	3.15
4	S	219	Y	0.08	21.5	7.20	2.70	4.50
4	S	142	Y	8.50	19.0	5.83	3.30	2.53
4	S	82-14	E	DEAD	-	-	-	-
4	S	81-54	E	10.00	21.5	6.80	3.15	3.65
4	S	81-50	E	1.00	24.0	7.08	4.05	3.03
4	S	82-33	E	0.00	20.0	7.90	3.80	4.10
4	S	81-55	E	3.50	24.0	6.10	2.85	3.25
4	S	81-51	E	0.50	21.5	7.75	3.65	4.10
4	S	341	R	0.50	23.5	6.80	2.85	3.95
4	S	81-37	R	2.50	26.5	7.35	3.95	3.40
4	S	344	R	1.50	24.0	7.63	4.05	3.58
4	S	81-03	R	3.00	25.5	7.75	3.30	4.45
2	G	616	K	DEAD	-	-	-	-
2	G	622	K	DEAD	-	-	-	-
2	G	609	K	DEAD	-	-	-	-
2	G	607	K	-	11.3	8.33	2.05	6.28
2	G	11	Y	-	20.0	8.60	1.73	6.87
2	G	26	Y	-	19.5	10.30	2.58	7.72
2	G	119	Y	-	18.8	9.30	2.98	6.32
2	G	7	Y	-	30.8	10.30	2.20	8.10
2	G	22	Y	-	19.8	7.63	2.05	5.58
2	G	204	D	-	23.8	9.15	2.58	6.57
2	G	228	D	-	15.3	8.75	1.65	7.10
2	G	49	D	-	16.5	8.33	1.93	6.40
2	G	146	D	-	13.0	9.30	2.58	6.72
2	G	238	D	-	23.0	7.50	2.58	4.92
2	G	145	D	-	23.0	9.75	2.98	6.77
2	G	6	D	-	25.8	8.05	3.10	4.95
2	G	64	D	-	25.8	9.15	2.73	6.42
2	G	217	B	-	20.0	10.05	3.30	6.75
2	G	84-18	B	-	19.0	9.80	2.30	7.50
2	G	82	B	-	15.3	7.63	2.25	5.38
4	G	90	K	DEAD	-	-	-	-
4	G	606	K	1.50	19.3	7.20	3.10	4.10
4	G	630	K	1.00	18.8	8.05	3.05	5.00
4	G	608	K	0.50	23.3	8.60	2.98	5.62
4	G	8	Y	0.00	21.3	9.50	2.58	6.92
4	G	183	Y	DEAD	-	-	-	-
4	G	240	Y	3.00	26.3	7.63	2.48	5.15
4	G	284	Y	0.50	29.8	8.75	2.85	5.90
4	G	192	Y	2.00	22.3	8.90	3.25	5.65
4	G	144	D	2.50	25.5	7.08	2.65	4.43
4	G	202	D	0.01	28.8	7.63	2.58	5.05
4	G	137	D	5.00	27.0	6.65	2.48	4.17
4	G	149	D	0.24	27.5	8.18	2.85	5.33
4	G	292	D	-	28.8	8.33	3.10	5.23
4	G	220	D	DEAD	-	-	-	-
4	G	111	D	8.50	21.3	9.75	2.53	7.22
4	G	31	D	1.00	27.5	10.30	3.05	7.25
4	G	15	B	1.50	18.3	9.50	2.48	7.02
4	G	216	B	3.50	23.3	9.80	2.58	7.22
4	G	215	B	0.50	24.5	10.35	2.25	8.10
M	S	792	E	-	22.8	7.35	3.40	3.95
M	S	230	E	-	28.8	7.23	3.40	3.83
M	S	108	E	-	21.8	7.20	3.45	3.75
M	S	702	E	-	21.5	7.20	3.45	3.75
M	S	110	E	-	22.5	5.83	3.00	2.83
M	S	712	E	DEAD	-	-	-	-
M	S	790	E	-	30.5	6.53	4.05	2.48
M	S	779	E	-	22.0	7.08	3.70	3.38
M	S	753	E	-	22.8	6.40	3.30	3.10
M	S	770	R	-	22.0	7.90	3.30	4.60
M	G	184	D	-	22.0	8.33	2.53	5.80
M	G	118	D	-	30.5	8.33	3.90	4.43
M	G	18	D	-	20.5	7.90	2.65	5.25
M	G	133	D	-	9.0	8.75	2.58	6.17
M	G	70	D	-	24.5	8.90	2.85	6.05
M	G	20	D	-	25.5	9.90	3.70	6.20
M	G	245	D	-	24.3	8.05	2.90	5.15
M	G	242	D	-	15.0	9.15	2.48	6.67
M	G	104	D	-	24.5	7.90	2.53	5.37
M	G	81	B	-	-	-	-	-
R	S	787	E	DEAD	-	-	-	-
R	S	797	E	DEAD	-	-	-	-
R	S	789	E	DEAD	-	-	-	-
R	S	81-59	E	DEAD	-	-	-	-
R	S	282	E	-	26.0	6.93	4.10	2.83
R	S	274	E	-	23.0	6.25	2.93	3.32
R	S	796	E	-	-	-	-	-
R	S	107	E	-	24.5	7.35	3.70	3.65
R	S	117	E	-	21.8	6.93	3.88	3.05
R	G	265	D	-	18.3	8.33	3.35	4.98
R	G	53	D	-	13.0	8.60	2.20	8.40
R	G	117	D	-	12.8	8.75	2.00	6.75
R	G	27	D	DEAD	-	-	-	-
R	G	293	D	-	18.5	7.08	1.85	5.23
R	G	30	D	-	17.5	7.35	2.65	4.70

APPENDIX 5

DATA FOR MID-MARCH 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
4	S	165	L	0.00
4	S	161	L	0.00
4	S	167	L	0.00
4	S	168	L	0.00
4	S	106	L	0.00
4	S	104	L	0.00
4	S	764	Y	0.00
4	S	144	Y	0.00
4	S	219	Y	0.00
4	S	142	Y	0.00
4	S	82-14	E	DEAD
4	S	81-54	E	0.00
4	S	81-50	E	0.00
4	S	82-33	E	0.00
4	S	81-55	E	0.00
4	S	81-51	E	0.00
4	S	341	R	0.00
4	S	81-37	R	0.00
4	S	344	R	0.00
4	S	81-03	R	0.00
4	G	90	K	DEAD
4	G	606	K	0.00
4	G	630	K	0.00
4	G	608	K	0.00
4	G	8	Y	0.00
4	G	183	Y	DEAD
4	G	240	Y	0.00
4	G	284	Y	0.00
4	G	192	Y	0.00
4	G	144	D	0.00
4	G	202	D	0.00
4	G	137	D	0.00
4	G	149	D	0.00
4	G	292	D	DEAD
4	G	220	D	DEAD
4	G	111	D	0.50
4	G	31	D	0.00
4	G	15	B	0.00
4	G	216	B	0.00
4	G	215	B	0.50

APPENDIX 5

DATA FOR THE BEGINNING OF APRIL 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (×100)
4	S	165	L	4.50
4	S	161	L	0.50
4	S	167	L	0.00
4	S	168	L	0.50
4	S	106	L	7.00
4	S	104	L	0.01
4	S	764	Y	0.50
4	S	144	Y	1.00
4	S	219	Y	0.00
4	S	142	Y	2.00
4	S	82-14	E	DEAD
4	S	81-54	E	1.50
4	S	81-50	E	0.05
4	S	82-33	E	2.50
4	S	81-55	E	0.50
4	S	81-51	E	0.50
4	S	341	R	1.50
4	S	81-37	R	0.11
4	S	344	R	1.50
4	S	81-03	R	-
4	G	90	K	DEAD
4	G	606	K	-
4	G	630	K	0.00
4	G	608	K	2.50
4	G	8	Y	0.50
4	G	183	Y	DEAD
4	G	240	Y	1.00
4	G	284	Y	1.00
4	G	192	Y	3.00
4	G	144	D	3.50
4	G	202	D	0.00
4	G	137	D	0.50
4	G	149	D	0.50
4	G	292	D	DEAD
4	G	220	D	DEAD
4	G	111	D	1.50
4	G	31	D	0.11
4	G	15	B	1.00
4	G	216	B	0.01
4	G	215	B	0.50

APPENDIX 5

DATA FOR THE END OF APRIL 1986

EXP - GRP	TY PE	ANIMAL - NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	12.00	2.00
2	S	155	L	11.75	0.50
2	S	157	L	11.00	21.50
2	S	112	L	14.50	0.00
2	S	154	L	15.50	4.50
2	S	788	L	15.75	2.00
2	S	291	Y	16.50	0.50
2	S	183	Y	17.25	1.00
2	S	325	Y	21.50	0.01
2	S	141	Y	18.00	19.00
2	S	81-58	E	DEAD	-
2	S	84-10	E	18.50	31.00
2	S	82-23	E	23.00	0.50
2	S	1-261	E	22.00	1.50
2	S	82-27	E	23.50	1.00
2	S	81-68	E	19.50	11.00
2	S	755	R	25.50	0.00
2	S	761	R	33.50	1.00
2	S	284	R	34.00	3.00
2	S	329	R	37.50	3.00
4	S	165	L	11.00	2.00
4	S	161	L	13.50	1.00
4	S	167	L	17.00	3.00
4	S	168	L	16.75	3.50
4	S	106	L	14.25	4.50
4	S	104	L	21.50	0.50
4	S	764	Y	17.50	6.00
4	S	144	Y	19.50	0.50
4	S	219	Y	17.00	0.00
4	S	142	Y	16.00	32.50
4	S	82-14	E	DEAD	-
4	S	81-54	E	20.50	7.50
4	S	81-50	E	22.75	11.50
4	S	82-33	E	26.75	0.50
4	S	81-55	E	23.00	1.00
4	S	81-51	E	23.00	12.50
4	S	341	R	25.00	7.00
4	S	81-37	R	34.50	2.50
4	S	344	R	30.25	1.00
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	9.75	0.50
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	14.00	2.00
2	G	204	D	14.75	1.50
2	G	228	D	15.75	6.00
2	G	49	D	13.00	3.50
2	G	146	D	12.25	20.50
2	G	238	D	15.00	0.00
2	G	145	D	15.00	4.50
2	G	6	D	21.25	0.00
2	G	64	D	17.00	0.50
2	G	217	B	13.50	1.00
2	G	84-18	B	15.50	1.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	6.00	0.01
4	G	608	K	9.00	2.00
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	12.25	0.00
4	G	284	Y	14.50	1.00
4	G	192	Y	12.50	11.00
4	G	144	D	DEAD	-
4	G	202	D	16.50	2.50
4	G	137	D	20.50	0.00
4	G	149	D	18.25	0.50
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	12.50	4.00
4	G	31	D	14.75	0.50
4	G	15	B	19.75	0.50
4	G	216	B	14.00	1.00
4	G	215	B	11.00	1.50
T	S	100	L	14.25	6.50
T	S	39	E	17.50	2.50
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	14.25	4.00
T	S	231	R	18.25	6.50
T	S	322	E	15.00	1.50
T	S	335	E	26.75	0.50
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	17.25	5.00
T	G	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	24.00	3.00
T	G	5	D	20.50	0.50
T	G	8	D	DEAD	-
T	G	FEM	Y	N.A.	-
T	G	6-12	K	17.50	7.00
T	G	BM2-5	K	11.25	1.50
T	G	1F2-5	K	12.00	2.50
T	G	2F2-5	K	10.75	2.50
T	G	20F	Y	14.25	0.50
T	G	7	D	18.00	6.00
T	G	16	D	16.50	1.00
T	G	42	Y	DEAD	-
T	G	49	D	22.75	0.50
T	G	BM2	K	9.00	1.50
M	S	792	E	13.00	0.50
M	S	230	E	18.00	0.50
M	S	108	E	12.00	22.50
M	S	702	E	15.00	0.50
M	S	110	E	16.50	1.50
M	S	712	E	DEAD	-
M	S	790	E	14.00	0.50
M	S	779	E	15.00	7.00
M	S	753	E	17.00	0.00
M	S	770	R	28.50	0.00
M	G	184	D	15.50	0.50
M	G	118	D	16.75	3.50
M	G	18	D	14.75	0.50
M	G	133	D	DEAD	-
M	G	70	D	13.75	4.00
M	G	20	D	17.00	0.50
M	G	245	D	12.00	5.00
M	G	242	D	11.75	8.00
M	G	104	D	14.50	0.50
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	19.50	1.00
R	S	274	E	26.50	0.00
R	S	796	E	DEAD	-
R	S	107	E	18.75	1.50
R	S	117	E	14.50	8.00
R	G	265	D	12.50	1.00
R	G	53	D	13.25	0.50
R	G	117	D	11.75	3.50
R	G	27	D	DEAD	-
R	G	293	D	15.00	2.50
R	G	30	D	18.00	1.00

APPENDIX 5

DATA FOR THE BEGINNING OF MAY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
2	S	307	L	0.00
2	S	155	L	0.00
2	S	157	L	0.00
2	S	112	L	0.00
2	S	154	L	0.00
2	S	788	L	0.00
2	S	291	Y	0.00
2	S	183	Y	0.00
2	S	325	Y	0.00
2	S	141	Y	0.00
2	S	81-58	E	DEAD
2	S	84-10	E	0.00
2	S	82-23	E	0.00
2	S	1-261	E	0.00
2	S	82-27	E	0.00
2	S	81-68	E	3.00
2	S	755	R	0.00
2	S	761	R	0.00
2	S	284	R	0.00
2	S	329	R	0.00
2	G	616	K	DEAD
2	G	622	K	DEAD
2	G	609	K	DEAD
2	G	607	K	DEAD
2	G	11	Y	0.00
2	G	26	Y	DEAD
2	G	119	Y	DEAD
2	G	7	Y	DEAD
2	G	22	Y	0.00
2	G	204	D	0.00
2	G	228	D	0.00
2	G	49	D	0.00
2	G	146	D	2.00
2	G	238	D	0.00
2	G	145	D	0.00
2	G	6	D	0.00
2	G	64	D	0.00
2	G	217	B	0.00
2	G	84-18	B	0.00
2	G	82	B	DEAD
M	S	792	E	0.00
M	S	230	E	0.00
M	S	108	E	0.00
M	S	702	E	0.00
M	S	110	E	0.00
M	S	712	E	DEAD
M	S	790	E	0.00
M	S	779	E	0.00
M	S	753	E	0.00
M	S	770	R	0.00
M	G	184	D	0.00
M	G	118	D	0.00
M	G	18	D	0.00
M	G	133	D	DEAD
M	G	70	D	0.00
M	G	20	D	0.00
M	G	245	D	0.00
M	G	242	D	0.00
M	G	104	D	0.00
M	G	81	B	DEAD

APPENDIX 5

DATA FOR THE END OF MAY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	12.00	0.50
2	S	155	L	13.00	0.00
2	S	157	L	12.50	1.00
2	S	112	L	16.00	0.00
2	S	154	L	18.00	0.00
2	S	788	L	17.75	0.01
2	S	291	Y	18.50	0.00
2	S	183	Y	18.50	0.50
2	S	325	Y	23.00	0.00
2	S	141	Y	17.00	1.50
2	S	81-58	E	DEAD	-
2	S	84-10	E	18.00	6.00
2	S	82-23	E	24.50	0.00
2	S	1-261	E	19.25	1.50
2	S	82-27	E	23.75	0.00
2	S	81-68	E	19.25	0.50
2	S	755	R	27.00	0.50
2	S	761	R	35.00	0.50
2	S	284	R	35.50	0.00
2	S	329	R	39.50	0.50
4	S	165	L	12.75	3.00
4	S	161	L	16.00	2.50
4	S	167	L	18.00	0.01
4	S	168	L	18.25	3.50
4	S	106	L	15.75	1.50
4	S	104	L	2.35	1.00
4	S	764	Y	1.75	1.00
4	S	144	Y	21.00	0.50
4	S	219	Y	18.50	0.00
4	S	142	Y	17.00	4.00
4	S	82-14	E	DEAD	-
4	S	81-54	E	18.50	2.50
4	S	81-50	E	23.75	6.50
4	S	82-33	E	25.00	0.50
4	S	81-55	E	24.25	0.50
4	S	81-51	E	24.00	0.50
4	S	341	R	26.75	4.50
4	S	81-37	R	37.00	2.00
4	S	344	R	24.00	0.00
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	11.25	0.00
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	14.75	0.00
2	G	204	D	16.00	0.00
2	G	228	D	17.25	0.50
2	G	49	D	14.50	0.00
2	G	146	D	13.00	2.00
2	G	238	D	16.75	0.00
2	G	145	D	17.00	0.00
2	G	6	D	20.50	0.00
2	G	64	D	18.25	0.00
2	G	217	B	14.75	0.00
2	G	84-18	B	16.75	0.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	8.75	0.50
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	13.25	1.00
4	G	284	Y	12.00	0.50
4	G	192	Y	12.50	0.19
4	G	144	D	DEAD	-
4	G	202	D	14.75	0.08
4	G	137	D	22.75	0.00
4	G	149	D	19.00	0.01
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	13.00	0.32
4	G	31	D	16.75	0.00
4	G	15	B	19.75	0.00
4	G	216	B	12.75	0.00
4	G	215	B	DEAD	-
T	S	100	L	13.50	0.50
T	S	39	E	16.75	0.04
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	14.00	1.00
T	S	231	R	18.00	4.00
T	S	322	E	15.00	1.50
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	25.50	1.50
T	G	5	D	21.75	1.50
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	17.00	1.00
T	G	BM2-5	K	10.50	0.50
T	G	1F2-5	K	12.00	1.50
T	G	2F2-5	K	11.00	0.50
T	G	20F	Y	13.00	1.50
T	G	7	D	17.25	-
T	G	16	D	16.75	0.50
T	G	42	Y	DEAD	-
T	G	49	D	24.50	0.50
T	G	BM2	K	9.25	0.50
M	S	792	E	15.00	4.00
M	S	230	E	20.00	0.01
M	S	108	E	14.50	0.50
M	S	702	E	16.00	0.50
M	S	110	E	18.00	1.50
M	S	712	E	DEAD	-
M	S	790	E	15.50	0.00
M	S	779	E	19.00	0.03
M	S	753	E	20.00	0.06
M	S	770	R	31.00	1.00
M	G	184	D	18.50	1.00
M	G	118	D	19.50	1.50
M	G	18	D	17.50	1.50
M	G	133	D	DEAD	-
M	G	70	D	16.00	0.50
M	G	20	D	19.50	0.00
M	G	245	D	12.50	9.00
M	G	242	D	12.00	11.00
M	G	104	D	16.00	0.50
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	18.75	0.00
R	S	274	E	26.00	0.00
R	S	796	E	DEAD	-
R	S	107	E	18.00	1.50
R	S	117	E	15.00	3.00
R	G	265	D	12.00	0.50
R	G	53	D	14.00	0.50
R	G	117	D	9.00	-
R	G	27	D	DEAD	-
R	G	293	D	14.00	0.11
R	G	30	D	16.25	0.03

APPENDIX 5

DATA FOR THE BEGINNING OF JUNE 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	PCV %	TOTAL PROTEIN (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
2	S	307	L	27.2	6.80	3.65	3.15
2	S	155	L	19.0	6.25	3.30	2.95
2	S	157	L	28.5	6.93	4.05	2.88
2	S	112	L	33.7	7.35	4.05	3.30
2	S	154	L	27.0	7.08	3.95	3.13
2	S	788	L	27.2	7.90	4.30	3.60
2	S	291	Y	30.0	8.90	3.40	5.50
2	S	183	Y	24.5	6.80	3.65	3.15
2	S	325	Y	21.9	6.80	3.45	3.35
2	S	141	Y	29.0	7.08	3.80	3.28
2	S	81-58	E	DEAD	-	-	-
2	S	84-10	E	23.7	7.35	3.45	3.90
2	S	82-23	E	23.0	7.75	3.80	3.95
2	S	1-261	E	24.0	8.05	3.40	4.65
2	S	82-27	E	23.0	8.18	3.25	4.93
2	S	81-68	E	37.8	7.20	2.70	4.50
2	S	755	R	28.0	7.35	3.45	3.90
2	S	761	R	23.5	8.33	4.10	4.23
2	S	284	R	24.0	7.08	3.70	3.38
2	S	329	R	27.8	7.20	4.05	3.15
4	S	165	L	25.0	7.48	4.60	2.88
4	S	161	L	28.8	6.80	4.10	2.70
4	S	167	L	31.0	7.00	4.43	2.57
4	S	168	L	32.0	8.33	4.30	4.03
4	S	106	L	29.0	6.93	4.60	2.33
4	S	104	L	32.5	6.65	3.88	2.77
4	S	764	Y	25.5	7.75	3.45	4.30
4	S	144	Y	27.5	7.75	3.95	3.80
4	S	219	Y	38.5	7.35	3.65	3.70
4	S	142	Y	30.0	9.03	4.30	4.73
4	S	82-14	E	DEAD	-	-	-
4	S	81-54	E	30.0	8.75	3.70	5.05
4	S	81-50	E	23.0	7.20	4.43	2.77
4	S	82-33	E	29.0	7.08	4.10	2.98
4	S	81-55	E	25.5	7.35	3.65	3.70
4	S	81-51	E	20.0	6.85	4.43	2.42
4	S	341	R	31.0	7.63	4.43	3.20
4	S	81-37	R	38.5	7.75	4.43	3.32
4	S	344	R	22.5	8.33	3.80	4.53
4	S	81-03	R	DEAD	-	-	-
2	G	616	K	DEAD	-	-	-
2	G	622	K	DEAD	-	-	-
2	G	609	K	DEAD	-	-	-
2	G	607	K	DEAD	-	-	-
2	G	11	Y	29.5	8.33	2.98	5.35
2	G	26	Y	DEAD	-	-	-
2	G	119	Y	DEAD	-	-	-
2	G	7	Y	DEAD	-	-	-
2	G	22	Y	26.5	8.75	2.98	5.77
2	G	204	D	27.5	8.90	3.45	5.45
2	G	228	D	21.3	8.60	2.48	6.12
2	G	49	D	24.3	8.90	2.98	5.92
2	G	146	D	22.8	8.60	3.35	5.25
2	G	238	D	25.5	8.05	3.50	4.55
2	G	145	D	30.3	8.18	3.35	4.83
2	G	6	D	26.5	9.15	3.05	6.10
2	G	64	D	35.3	9.80	4.10	5.70
2	G	217	B	23.5	8.75	3.50	5.25
2	G	84-18	B	17.8	7.75	2.48	5.27
2	G	82	B	DEAD	-	-	-
4	G	90	K	DEAD	-	-	-
4	G	606	K	DEAD	-	-	-
4	G	630	K	DEAD	-	-	-
4	G	608	K	26.5	7.90	3.10	4.80
4	G	8	Y	DEAD	-	-	-
4	G	183	Y	DEAD	-	-	-
4	G	240	Y	26.5	7.63	3.10	4.53
4	G	284	Y	26.8	6.80	2.00	4.80
4	G	192	Y	21.3	7.75	2.98	4.77
4	G	144	D	DEAD	-	-	-
4	G	202	D	33.3	6.93	3.25	3.68
4	G	137	D	36.0	8.33	3.30	5.03
4	G	149	D	29.3	7.48	3.30	4.18
4	G	292	D	DEAD	-	-	-
4	G	220	D	DEAD	-	-	-
4	G	111	D	29.8	7.75	3.25	4.50
4	G	31	D	23.5	7.08	3.50	3.58
4	G	15	B	25.8	8.18	3.35	4.83
4	G	216	B	24.3	9.03	2.00	7.03
4	G	215	B	DEAD	-	-	-
M	S	792	E	38.5	7.48	4.43	3.05
M	S	230	E	30.0	9.30	3.80	5.50
M	S	108	E	28.0	8.05	4.30	3.75
M	S	702	E	36.8	6.93	3.30	3.63
M	S	110	E	38.0	8.60	4.10	4.50
M	S	712	E	DEAD	-	-	-
M	S	790	E	36.8	10.35	4.10	6.25
M	S	779	E	31.0	7.63	3.70	3.93
M	S	753	E	28.0	7.63	3.80	3.83
M	S	770	R	29.0	7.48	4.10	3.38
M	G	184	D	25.0	7.08	2.90	4.18
M	G	118	D	29.5	7.35	3.50	3.85
M	G	18	D	27.0	8.05	3.25	4.80
M	G	133	D	DEAD	-	-	-
M	G	70	D	23.0	6.80	2.98	3.82
M	G	20	D	30.0	7.08	3.25	3.83
M	G	245	D	21.0	6.93	3.75	3.18
M	G	242	D	15.5	7.35	2.53	4.82
M	G	104	D	21.8	6.93	2.98	3.95
M	G	81	B	DEAD	-	-	-
R	S	787	E	DEAD	-	-	-
R	S	797	E	DEAD	-	-	-
R	S	789	E	DEAD	-	-	-
R	S	81-59	E	DEAD	-	-	-
R	S	282	E	33.5	7.35	4.43	2.92
R	S	274	E	27.5	6.65	4.30	2.35
R	S	796	E	DEAD	-	-	-
R	S	107	E	30.0	7.48	4.30	3.18
R	S	117	E	21.0	8.33	3.30	5.03
R	G	265	D	16.0	9.15	2.20	6.95
R	G	53	D	28.8	7.20	1.65	5.55
R	G	117	D	11.8	6.53	2.20	4.33
R	G	27	D	DEAD	-	-	-
R	G	293	D	16.8	8.18	1.93	6.25
R	G	30	D	17.8	7.48	2.58	4.90

APPENDIX 5

DATA FOR THE END OF JUNE 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	13.00	0.50
2	S	155	L	13.50	2.00
2	S	157	L	13.25	13.50
2	S	112	L	16.50	0.50
2	S	154	L	19.50	1.00
2	S	788	L	18.25	2.50
2	S	291	Y	19.75	0.50
2	S	183	Y	16.75	0.18
2	S	325	Y	23.00	0.00
2	S	141	Y	16.00	7.00
2	S	81-58	E	DEAD	-
2	S	84-10	E	16.50	42.00
2	S	82-23	E	24.50	0.00
2	S	1-261	E	18.75	6.00
2	S	82-27	E	22.75	1.00
2	S	81-68	E	19.50	3.50
2	S	755	R	27.25	0.00
2	S	761	R	35.25	5.00
2	S	284	R	35.75	2.50
2	S	329	R	39.50	0.33
4	S	165	L	13.00	9.50
4	S	161	L	16.50	6.00
4	S	167	L	18.50	2.00
4	S	168	L	18.25	6.50
4	S	106	L	16.00	2.50
4	S	104	L	22.50	0.00
4	S	764	Y	19.50	0.50
4	S	144	Y	22.50	0.50
4	S	219	Y	19.50	0.12
4	S	142	Y	16.00	12.50
4	S	82-14	E	DEAD	-
4	S	81-54	E	22.00	4.00
4	S	81-50	E	22.00	4.50
4	S	82-33	E	22.75	0.07
4	S	81-55	E	24.50	0.01
4	S	81-51	E	23.25	2.00
4	S	341	R	26.00	2.00
4	S	81-37	R	37.25	1.50
4	S	344	R	34.50	1.00
2	G	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	12.00	0.50
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	16.00	0.50
2	G	204	D	16.50	0.00
2	G	228	D	17.00	1.00
2	G	49	D	15.00	0.00
2	G	146	D	13.25	11.50
2	G	238	D	16.50	0.00
2	G	145	D	17.00	0.50
2	G	6	D	19.50	0.01
2	G	64	D	18.25	0.50
2	G	217	B	DEAD	-
2	G	84-18	B	17.25	1.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	9.00	1.00
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	14.25	0.23
4	G	284	Y	12.50	0.20
4	G	192	Y	13.25	1.50
4	G	144	D	DEAD	-
4	G	202	D	18.50	0.50
4	G	137	D	19.75	1.50
4	G	149	D	18.00	0.50
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	14.00	7.50
4	G	31	D	15.25	2.50
4	G	15	B	20.50	2.00
4	G	216	B	13.50	1.00
4	G	215	B	DEAD	-
T	S	100	L	12.50	10.00
T	S	39	E	15.13	1.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	15.00	2.00
T	S	231	R	18.50	4.50
T	S	322	E	17.75	0.12
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	G	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	28.25	0.50
T	G	5	D	23.00	1.50
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	17.00	3.00
T	G	BM2-5	K	11.25	0.50
T	G	1F2-5	K	12.50	1.50
T	G	2F2-5	K	9.50	N.A.
T	G	20F	Y	DEAD	-
T	G	7	D	17.00	2.50
T	G	16	D	DEAD	0.50
T	G	42	Y	DEAD	-
T	G	49	D	22.25	3.00
E	S	BM2	K	8.87	0.50
E	S	792	E	15.50	3.50
E	S	230	E	21.50	2.00
E	S	108	E	15.00	0.00
E	S	702	E	18.00	0.50
E	S	110	E	18.75	0.50
E	S	712	E	DEAD	-
E	S	790	E	16.25	0.04
E	S	779	E	20.25	2.00
E	S	753	E	21.50	0.00
E	S	770	R	32.00	0.50
E	G	184	D	18.75	0.00
E	G	118	D	20.00	0.01
E	G	18	D	17.75	0.00
E	G	133	D	DEAD	-
E	G	70	D	16.25	0.03
E	G	20	D	19.75	0.00
E	G	245	D	11.75	0.00
E	G	242	D	DEAD	-
E	G	104	D	16.75	0.00
E	G	B1	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	19.00	1.00
R	S	274	E	25.50	0.00
R	S	796	E	DEAD	-
R	S	107	E	16.25	2.00
R	S	117	E	14.50	5.00
R	G	265	D	11.25	1.50
R	G	53	D	13.25	2.00
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	14.00	3.50
R	G	30	D	15.50	2.00

APPENDIX 5

DATA FOR MID-JULY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
4	S	165	L	0.00
4	S	161	L	0.00
4	S	167	L	0.00
4	S	168	L	0.00
4	S	106	L	0.00
4	S	104	L	0.00
4	S	764	Y	0.00
4	S	144	Y	0.00
4	S	219	Y	0.00
4	S	142	Y	0.00
4	S	82-14	E	DEAD
4	S	81-54	E	0.00
4	S	81-50	E	0.00
4	S	82-33	E	0.00
4	S	81-55	E	0.00
4	S	81-51	E	0.00
4	S	341	R	0.00
4	S	81-37	R	0.00
4	S	344	R	0.00
4	S	81-03	R	DEAD
4	G	90	K	DEAD
4	G	606	K	DEAD
4	G	630	K	DEAD
4	G	608	K	0.00
4	G	8	Y	DEAD
4	G	183	Y	DEAD
4	G	240	Y	0.00
4	G	284	Y	0.00
4	G	192	Y	0.00
4	G	144	D	DEAD
4	G	202	D	0.00
4	G	137	D	0.00
4	G	149	D	0.00
4	G	292	D	DEAD
4	G	220	D	DEAD
4	G	111	D	0.00
4	G	31	D	0.00
4	G	15	B	0.00
4	G	216	B	0.00
4	G	215	B	DEAD

APPENDIX 5

DATA FOR THE END OF JULY 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	13.50	0.50
2	S	155	L	14.00	0.50
2	S	157	L	13.75	0.50
2	S	112	L	17.00	0.00
2	S	154	L	20.00	0.50
2	S	788	L	19.00	0.00
2	S	291	Y	19.75	0.00
2	S	183	Y	17.75	0.00
2	S	325	Y	23.75	0.00
2	S	141	Y	15.50	0.00
2	S	81-58	E	DEAD	-
2	S	84-10	E	17.25	1.50
2	S	82-23	E	25.50	0.00
2	S	1-261	E	17.50	3.00
2	S	82-27	E	22.25	0.00
2	S	81-68	E	20.75	2.50
2	S	755	R	27.50	0.00
2	S	761	R	35.00	0.00
2	S	284	R	36.00	0.00
2	S	329	R	40.00	0.00
4	S	165	L	12.25	0.00
4	S	161	L	17.00	0.00
4	S	167	L	19.50	0.01
4	S	168	L	19.00	0.00
4	S	106	L	15.50	0.00
4	S	104	L	23.25	0.00
4	S	764	Y	20.00	0.00
4	S	144	Y	22.75	0.00
4	S	219	Y	20.00	0.00
4	S	142	Y	15.25	0.00
4	S	82-14	E	DEAD	-
4	S	81-54	E	23.25	0.00
4	S	81-50	E	22.00	0.00
4	S	82-33	E	22.00	0.00
4	S	81-55	E	23.00	0.00
4	S	81-51	E	23.50	0.00
4	S	341	R	26.50	0.00
4	S	81-37	R	37.50	0.00
4	S	344	R	34.00	0.00
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	11.75	0.03
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	16.75	1.00
2	G	204	D	17.00	1.00
2	G	228	D	17.00	14.00
2	G	49	D	15.50	2.50
2	G	146	D	12.25	83.50
2	G	238	D	16.75	0.50
2	G	145	D	17.00	2.00
2	G	6	D	18.75	0.30
2	G	64	D	17.75	2.00
2	G	217	B	DEAD	-
2	G	84-18	B	16.50	4.50
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	9.25	0.01
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	14.75	0.06
4	G	284	Y	12.75	0.50
4	G	192	Y	13.00	0.50
4	G	144	D	DEAD	-
4	G	202	D	18.00	0.50
4	G	137	D	17.50	0.50
4	G	149	D	18.50	0.50
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	14.25	0.00
4	G	31	D	15.50	0.04
4	G	15	B	19.00	0.12
4	G	216	B	13.25	0.00
4	G	215	B	DEAD	-
T	S	100	L	MISSING	-
T	S	39	E	14.25	1.50
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	DEAD	-
T	S	231	R	21.00	4.00
T	S	322	E	18.00	4.50
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	22.00	4.00
T	G	5	D	21.50	2.00
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	16.00	1.00
T	G	BM2-5	K	DEAD	-
T	G	1F2-5	K	13.00	1.50
T	G	2F2-5	K	11.25	0.00
T	G	20F	Y	DEAD	-
T	G	7	D	15.50	9.00
T	G	16	D	DEAD	-
T	G	42	Y	DEAD	-
T	G	49	D	DEAD	-
T	G	BM7	K	7.75	0.00
M	S	792	E	15.75	3.00
M	S	230	E	21.75	4.00
M	S	108	E	14.75	1.50
M	S	702	E	17.25	6.00
M	S	110	E	18.00	2.00
M	S	712	E	DEAD	-
M	S	790	E	16.00	0.00
M	S	779	E	20.25	0.50
M	S	753	E	21.50	0.00
M	S	770	R	30.50	9.00
M	G	184	D	19.00	0.50
M	G	118	D	21.00	5.50
M	G	18	D	17.75	0.12
M	G	133	D	DEAD	-
M	G	70	D	17.25	3.00
M	G	20	D	19.50	3.50
M	G	245	D	DEAD	-
M	G	242	D	DEAD	-
M	G	104	D	16.50	2.00
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	17.00	0.03
R	S	274	E	22.00	0.00
R	S	796	E	DEAD	-
R	S	107	E	13.75	17.50
R	S	117	E	13.50	1.50
R	G	265	D	10.50	2.00
R	G	53	D	12.00	3.50
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	13.00	28.00
R	G	30	D	14.50	3.00

APPENDIX 5

DATA FOR THE BEGINNING OF AUGUST 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
2	S	307	L	0.00
2	S	155	L	0.00
2	S	157	L	0.00
2	S	112	L	0.00
2	S	154	L	0.00
2	S	788	L	0.00
2	S	291	Y	0.00
2	S	183	Y	0.00
2	S	325	Y	0.00
2	S	141	Y	0.00
2	S	81-58	E	DEAD
2	S	84-10	E	0.00
2	S	82-23	E	0.00
2	S	1-261	E	0.00
2	S	82-27	E	0.00
2	S	81-68	E	0.00
2	S	755	R	0.00
2	S	761	R	0.00
2	S	284	R	0.00
2	S	329	R	0.00
2	G	616	K	DEAD
2	G	622	K	DEAD
2	G	609	K	DEAD
2	G	607	K	DEAD
2	G	11	Y	0.00
2	G	26	Y	DEAD
2	G	119	Y	DEAD
2	G	7	Y	DEAD
2	G	22	Y	0.00
2	G	204	Y	0.00
2	G	228	D	0.00
2	G	49	D	0.00
2	G	146	D	0.00
2	G	238	D	0.00
2	G	145	D	0.00
2	G	6	D	0.00
2	G	64	D	0.00
2	G	217	B	DEAD
2	G	84-18	B	0.00
2	G	82	B	DEAD
M	S	792	E	0.00
M	S	230	E	0.00
M	S	108	E	0.00
M	S	702	E	0.00
M	S	110	E	0.00
M	S	712	E	DEAD
M	S	790	E	0.00
M	S	779	E	0.50
M	S	753	E	0.00
M	S	770	R	0.00
M	G	184	D	0.00
M	G	118	D	0.50
M	G	18	D	0.00
M	G	133	D	DEAD
M	G	70	D	0.00
M	G	20	D	0.00
M	G	245	D	DEAD
M	G	242	D	DEAD
M	G	104	D	0.00
M	G	81	B	DEAD

APPENDIX 5

DATA FOR THE END OF AUGUST 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	14.00	0.50
2	S	155	L	14.25	0.01
2	S	157	L	14.00	1.50
2	S	112	L	17.00	0.12
2	S	154	L	20.50	0.03
2	S	788	L	19.25	0.00
2	S	291	Y	20.00	1.00
2	S	183	Y	18.00	0.50
2	S	325	Y	24.00	0.00
2	S	141	Y	16.00	0.00
2	S	81-58	E	DEAD	-
2	S	84-10	E	17.50	3.50
2	S	82-23	E	25.50	0.04
2	S	1-261	E	17.50	0.44
2	S	82-27	E	22.50	0.03
2	S	81-68	E	21.00	3.00
2	S	755	R	28.00	0.50
2	S	761	R	35.25	0.10
2	S	284	R	36.25	1.50
2	S	329	R	40.50	0.00
4	S	165	L	12.50	0.50
4	S	161	L	17.50	1.00
4	S	167	L	19.75	0.00
4	S	168	L	19.25	0.50
4	S	106	L	16.00	0.50
4	S	104	L	23.50	0.00
4	S	764	Y	20.00	0.00
4	S	144	Y	23.00	1.00
4	S	219	Y	20.00	0.50
4	S	142	Y	15.50	0.00
4	S	82-14	E	DEAD	-
4	S	81-54	E	23.50	1.50
4	S	81-50	E	22.50	0.50
4	S	82-33	E	22.00	0.03
4	S	81-55	E	23.00	0.00
4	S	81-51	E	24.50	0.00
4	S	341	R	27.00	1.00
4	S	81-37	R	38.00	1.50
4	S	344	R	28.00	0.00
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	12.50	0.00
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	17.50	0.03
2	G	204	D	17.50	0.01
2	G	228	D	15.50	0.50
2	G	49	D	16.50	0.00
2	G	146	D	11.50	3.00
2	G	238	D	17.00	0.00
2	G	145	D	17.00	0.50
2	G	6	D	19.00	0.00
2	G	64	D	18.75	0.00
2	G	217	B	DEAD	-
2	G	84-18	B	18.25	0.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	9.25	0.00
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	15.00	0.04
4	G	284	Y	13.25	0.00
4	G	192	Y	11.50	0.00
4	G	144	D	DEAD	-
4	G	202	D	19.00	1.50
4	G	137	D	17.75	0.50
4	G	149	D	19.00	0.50
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	14.50	1.50
4	G	31	D	16.25	1.00
4	G	15	B	21.25	0.30
4	G	216	B	13.50	0.50
4	G	215	B	DEAD	-
T	S	100	L	MISSING	-
T	S	39	E	13.50	1.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	DEAD	-
T	S	231	R	22.00	2.50
T	S	322	E	18.75	1.50
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	21.75	2.00
T	G	5	D	18.00	1.00
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	14.25	0.00
T	G	BM2-5	K	DEAD?	-
T	G	1F2-5	K	14.25	0.00
T	G	2F2-5	K	10.75	0.50
T	G	20F	Y	DEAD	-
T	G	7	D	16.00	1.00
T	G	16	D	DEAD	-
T	G	42	Y	DEAD	-
T	G	49	D	DEAD	-
T	G	BM2	K	9.00	2.00
M	S	792	E	16.25	0.01
M	S	230	E	24.00	0.03
M	S	108	E	15.75	0.00
M	S	702	E	18.50	0.50
M	S	110	E	18.75	0.03
M	S	712	E	DEAD	-
M	S	790	E	16.50	0.00
M	S	779	E	22.25	0.00
M	S	753	E	23.00	0.00
M	S	770	R	32.50	0.00
M	G	184	D	20.75	0.00
M	G	118	D	20.00	0.00
M	G	18	D	19.00	0.50
M	G	133	D	DEAD	-
M	G	70	D	18.50	0.00
M	G	20	D	20.00	1.00
M	G	245	D	DEAD	-
M	G	242	D	DEAD	-
M	G	104	D	17.50	0.00
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	16.75	0.00
R	S	274	E	22.00	0.50
R	S	796	E	DEAD	-
R	S	107	E	13.00	3.50
R	S	117	E	13.25	12.00
R	G	265	D	9.75	2.50
R	G	53	D	11.50	1.00
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	12.25	12.50
R	G	30	D	14.25	0.50

APPENDIX 5

DATA FOR THE BEGINNING OF SEPTEMBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	PCV %	TOTAL PROTEIN (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
2	S	307	L	23.8	7.00	2.60	4.40
2	S	155	L	29.8	7.75	3.40	4.35
2	S	157	L	28.3	7.48	2.93	4.55
2	S	112	L	25.3	8.90	2.93	5.97
2	S	154	L	27.3	8.18	3.25	4.93
2	S	788	L	31.8	8.33	3.25	5.08
2	S	291	Y	28.5	7.35	3.70	3.65
2	S	183	Y	23.3	7.20	3.10	4.10
2	S	325	Y	26.3	8.05	2.93	5.12
2	S	141	Y	30.8	6.80	2.75	4.05
2	S	81-58	E	DEAD	-	-	-
2	S	84-10	E	23.3	6.65	3.10	3.55
2	S	82-23	E	31.3	8.95	3.88	5.07
2	S	1-261	E	21.8	9.50	2.60	6.90
2	S	82-27	E	28.5	9.03	3.40	5.63
2	S	81-68	E	28.3	8.60	2.93	5.67
2	S	755	R	31.5	7.08	3.10	3.98
2	S	761	R	25.3	7.08	3.10	3.98
2	S	284	R	24.0	8.90	2.93	5.97
2	S	329	R	33.8	8.18	3.55	4.63
4	S	165	L	31.0	8.33	3.70	4.63
4	S	161	L	34.3	7.00	4.20	2.80
4	S	167	L	30.8	8.75	2.93	5.82
4	S	168	L	35.3	7.35	3.70	3.65
4	S	106	L	27.5	7.08	3.88	3.20
4	S	104	L	27.8	6.93	4.20	2.73
4	S	764	Y	28.8	9.00	3.88	5.12
4	S	144	Y	30.0	8.05	4.35	3.70
4	S	219	Y	24.0	8.75	3.70	5.05
4	S	142	Y	26.3	7.08	3.98	7.08
4	S	82-14	E	DEAD	-	-	-
4	S	81-54	E	26.3	7.63	3.15	4.48
4	S	81-50	E	24.0	9.00	3.25	5.75
4	S	82-33	E	33.0	8.05	4.20	3.85
4	S	81-55	E	31.8	8.90	5.00	3.90
4	S	81-51	E	25.0	8.60	3.80	4.80
4	S	341	R	33.5	8.60	3.25	5.35
4	S	81-37	R	27.3	9.75	3.88	5.87
4	S	344	R	27.3	8.90	3.25	5.65
4	S	81-03	R	DEAD	-	-	-
2	G	616	K	DEAD	-	-	-
2	G	622	K	DEAD	-	-	-
2	G	609	K	DEAD	-	-	-
2	G	607	K	DEAD	-	-	-
2	G	11	Y	27.0	9.90	3.35	6.55
2	G	26	Y	DEAD	-	-	-
2	G	119	Y	DEAD	-	-	-
2	G	7	Y	DEAD	-	-	-
2	G	22	Y	14.0	8.90	5.45	3.45
2	G	204	D	33.8	8.90	3.70	5.20
2	G	228	D	15.5	9.30	2.00	7.30
2	G	49	D	26.3	9.15	3.95	5.20
2	G	146	D	32.8	9.30	3.55	5.75
2	G	238	D	29.5	9.00	3.05	5.95
2	G	145	D	34.0	9.15	3.55	5.60
2	G	6	D	31.5	9.15	2.53	5.60
2	G	64	D	36.0	8.90	3.18	5.72
2	G	217	B	DEAD	-	-	-
2	G	84-18	B	32.0	9.75	2.90	6.85
2	G	82	B	DEAD	-	-	-
4	G	90	K	DEAD	-	-	-
4	G	606	K	DEAD	-	-	-
4	G	630	K	DEAD	-	-	-
4	G	608	K	29.8	7.50	2.73	4.77
4	G	8	Y	DEAD	-	-	-
4	G	183	Y	DEAD	-	-	-
4	G	240	Y	27.3	8.18	3.10	5.08
4	G	284	Y	26.3	10.30	3.05	7.25
4	G	192	Y	19.5	8.05	2.65	5.40
4	G	144	D	DEAD	-	-	-
4	G	202	D	23.8	9.90	3.45	6.45
4	G	137	D	28.8	8.60	2.90	5.70
4	G	149	D	14.0	9.15	3.35	5.80
4	G	292	D	DEAD	-	-	-
4	G	220	D	DEAD	-	-	-
4	G	111	D	31.8	9.75	3.10	6.65
4	G	31	D	31.5	8.75	3.45	5.30
4	G	15	B	27.8	9.15	1.93	7.22
4	G	216	B	21.3	10.10	2.53	7.57
4	G	215	B	DEAD	-	-	-
M	S	792	E	31.3	8.18	4.20	3.98
M	S	230	E	32.5	7.63	4.85	2.78
M	S	108	E	31.5	8.75	3.25	5.50
M	S	702	E	38.8	8.90	5.33	3.57
M	S	110	E	38.0	7.75	3.40	4.35
M	S	712	E	DEAD	-	-	-
M	S	790	E	41.8	7.75	4.68	3.07
M	S	779	E	34.3	8.33	3.88	4.45
M	S	753	E	31.8	8.18	4.68	3.50
M	S	770	R	27.0	8.33	4.50	3.83
M	G	184	D	32.0	8.33	2.65	5.68
M	G	118	D	36.5	8.33	3.70	4.63
M	G	18	D	36.3	8.60	3.18	5.42
M	G	133	D	DEAD	-	-	-
M	G	70	D	37.0	10.05	3.83	6.22
M	G	20	D	36.0	9.80	4.10	5.70
M	G	245	D	DEAD	-	-	-
M	G	242	D	DEAD	-	-	-
M	G	104	D	30.0	9.15	3.30	5.85
M	G	81	B	DEAD	-	-	-
R	S	787	E	DEAD	-	-	-
R	S	797	E	DEAD	-	-	-
R	S	789	E	DEAD	-	-	-
R	S	81-59	E	DEAD	-	-	-
R	S	282	E	26.0	7.58	3.25	4.33
R	S	274	E	24.3	7.35	3.45	3.90
R	S	796	E	DEAD	-	-	-
R	S	107	E	26.5	7.30	3.25	4.05
R	S	117	E	21.5	8.18	2.60	5.58
R	G	265	D	12.0	6.93	1.85	5.08
R	G	53	D	19.3	9.15	1.85	7.30
R	G	117	D	DEAD	-	-	-
R	G	27	D	DEAD	-	-	-
R	G	293	D	9.0	5.70	1.60	4.10
R	G	30	D	22.8	8.13	2.13	6.00

APPENDIX 5

DATA FOR MID-SEPTEMBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
4	S	165	L	0.00
4	S	161	L	0.00
4	S	167	L	0.00
4	S	168	L	0.00
4	S	106	L	0.00
4	S	104	L	0.00
4	S	764	Y	0.00
4	S	144	Y	0.00
4	S	219	Y	0.00
4	S	142	Y	0.00
4	S	82-14	E	DEAD
4	S	81-54	E	0.00
4	S	81-50	E	0.00
4	S	82-33	E	0.00
4	S	81-55	E	0.00
4	S	81-51	E	0.00
4	S	341	R	0.00
4	S	81-37	R	0.00
4	S	344	R	0.00
4	S	81-03	R	DEAD
4	G	90	K	DEAD
4	G	606	K	DEAD
4	G	630	K	DEAD
4	G	608	K	0.00
4	G	8	Y	DEAD
4	G	183	Y	DEAD
4	G	240	Y	0.01
4	G	284	Y	0.00
4	G	192	Y	0.00
4	G	144	D	DEAD
4	G	202	D	0.00
4	G	137	D	0.01
4	G	149	D	0.00
4	G	292	D	DEAD
4	G	220	D	DEAD
4	G	111	D	0.01
4	G	31	D	0.00
4	G	15	B	0.00
4	G	216	B	0.01
4	G	215	B	DEAD

APPENDIX 5

DATA FOR THE END OF SEPTEMBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	16.00	1.50
2	S	155	L	16.00	1.00
2	S	157	L	14.50	1.50
2	S	112	L	17.50	4.50
2	S	154	L	22.50	2.00
2	S	788	L	20.50	0.00
2	S	291	Y	17.50	0.50
2	S	183	Y	20.00	0.00
2	S	325	Y	24.00	0.07
2	S	141	Y	16.50	0.50
2	S	81-58	E	DEAD	-
2	S	84-10	E	19.50	2.00
2	S	82-23	E	29.50	1.00
2	S	1-261	E	19.75	0.50
2	S	82-27	E	24.00	0.00
2	S	81-68	E	22.50	10.50
2	S	755	R	29.00	1.00
2	S	761	R	37.50	4.00
2	S	284	R	37.00	0.50
2	S	329	R	40.50	0.01
4	S	165	L	14.25	0.50
4	S	161	L	18.50	1.00
4	S	167	L	22.50	0.50
4	S	168	L	22.00	3.00
4	S	106	L	13.75	8.50
4	S	104	L	19.00	9.00
4	S	764	Y	22.50	0.00
4	S	144	Y	18.00	0.50
4	S	219	Y	21.00	0.50
4	S	142	Y	17.50	0.00
4	S	82-14	E	DEAD	-
4	S	81-54	E	22.00	0.50
4	S	81-50	E	25.00	2.50
4	S	82-33	E	24.50	0.00
4	S	81-55	E	26.00	0.01
4	S	81-51	E	26.00	0.00
4	S	341	R	27.00	0.07
4	S	81-37	R	38.00	0.00
4	S	344	R	29.00	4.00
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	13.00	0.50
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	19.00	1.50
2	G	204	D	18.00	0.07
2	G	228	D	17.50	2.50
2	G	49	D	16.25	1.00
2	G	146	D	11.25	48.50
2	G	238	D	17.75	0.03
2	G	145	D	7.50	0.50
2	G	6	D	18.75	3.00
2	G	64	D	19.50	1.50
2	G	217	B	DEAD	-
2	G	84-18	B	17.00	14.50
4	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	10.00	0.00
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	16.75	0.50
4	G	284	Y	14.25	0.00
4	G	192	Y	12.75	0.00
4	G	144	D	DEAD	-
4	G	202	D	22.00	0.00
4	G	137	D	17.00	0.00
4	G	149	D	19.50	0.00
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	15.75	0.01
4	G	31	D	18.75	0.00
4	G	15	B	19.50	0.01
4	G	216	B	13.50	0.00
4	G	215	B	DEAD	-
T	S	100	L	MISSING	-
T	S	39	E	13.50	24.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	DEAD	-
T	S	231	R	22.25	23.50
T	S	322	E	15.50	45.00
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	G	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	22.50	5.50
T	G	5	D	19.00	11.00
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	18.50	4.00
T	G	BM2-5	K	DEAD	-
T	G	1F2-5	K	15.75	6.50
T	G	2F2-5	K	12.75	16.00
T	G	20F	Y	DEAD	-
T	G	7	D	15.50	14.00
T	G	16	D	DEAD	-
T	G	42	Y	DEAD	-
T	G	49	D	DEAD	-
M	S	BM2	K	11.00	24.50
M	S	792	E	16.25	13.50
M	S	230	E	24.50	0.50
M	S	108	E	16.00	1.00
M	S	702	E	18.25	3.50
M	S	110	E	18.50	0.16
M	S	712	E	DEAD	-
M	S	790	E	16.50	1.00
M	S	779	E	23.00	0.00
M	S	753	E	23.00	0.00
M	S	770	R	33.00	3.50
M	G	184	D	22.50	6.50
M	G	118	D	20.50	2.00
M	G	18	D	19.50	35.00
M	G	133	D	DEAD	-
M	G	70	D	18.75	0.50
M	G	20	D	20.75	9.50
M	G	245	D	DEAD	-
M	G	242	D	DEAD	-
M	G	104	D	17.50	0.12
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	18.00	1.50
R	S	274	E	23.50	2.00
R	S	796	E	DEAD	-
R	S	107	E	13.00	99.99
R	S	117	E	13.00	36.00
R	G	265	D	9.50	24.50
R	G	53	D	11.00	1.50
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	DEAD	-
R	G	30	D	14.75	3.50

APPENDIX 5

DATA FOR THE BEGINNING OF OCTOBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	FAECAL e.p.g. (x100)
4	S	165	L	0.00
4	S	161	L	0.00
4	S	167	L	0.00
4	S	168	L	0.00
4	S	106	L	0.00
4	S	104	L	0.00
4	S	764	Y	0.00
4	S	144	Y	0.00
4	S	219	Y	0.00
4	S	142	Y	0.00
4	S	82-14	E	DEAD
4	S	81-54	E	0.00
4	S	81-50	E	0.00
4	S	82-33	E	0.00
4	S	81-55	E	0.00
4	S	81-51	E	0.00
4	S	81-51	E	0.00
4	S	341	R	0.00
4	S	81-37	R	0.00
4	S	344	R	0.00
4	S	81-03	R	DEAD
4	G	90	K	DEAD
4	G	606	K	DEAD
4	G	630	K	DEAD
4	G	608	K	0.00
4	G	8	Y	DEAD
4	G	183	Y	DEAD
4	G	240	Y	0.01
4	G	284	Y	0.00
4	G	192	Y	0.00
4	G	144	D	DEAD
4	G	202	D	0.00
4	G	137	D	0.01
4	G	149	D	0.00
4	G	292	D	DEAD
4	G	220	D	DEAD
4	G	111	D	0.01
4	G	31	D	0.00
4	G	15	B	0.00
4	G	216	B	0.01
4	G	215	B	DEAD

APPENDIX 5

DATA FOR THE END OF OCTOBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL e.p.g. (x100)
2	S	307	L	17.00	1.00
2	S	155	L	16.50	0.05
2	S	157	L	15.50	0.50
2	S	112	L	18.00	2.00
2	S	154	L	23.00	2.00
2	S	788	L	21.00	1.00
2	S	291	Y	17.00	1.00
2	S	183	Y	21.00	0.50
2	S	325	Y	24.75	0.00
2	S	141	Y	16.25	0.50
2	S	81-58	E	DEAD	-
2	S	84-10	E	20.00	4.50
2	S	82-23	E	24.50	0.01
2	S	1-261	E	21.00	0.50
2	S	82-27	E	26.25	0.01
2	S	81-68	E	19.25	5.50
2	S	755	R	27.50	0.00
2	S	761	R	33.00	0.11
2	S	284	R	35.50	1.50
2	S	329	R	36.75	0.00
4	S	165	L	14.50	0.50
4	S	161	L	19.25	0.00
4	S	167	L	23.25	0.50
4	S	168	L	21.50	2.00
4	S	106	L	13.25	2.00
4	S	104	L	16.00	5.00
4	S	764	Y	24.25	0.00
4	S	144	Y	17.50	0.00
4	S	219	Y	22.75	0.50
4	S	142	Y	18.50	0.05
4	S	82-14	E	DEAD	-
4	S	81-54	E	21.50	0.00
4	S	81-50	E	26.75	0.50
4	S	82-33	E	26.25	0.00
4	S	81-55	E	28.25	0.00
4	S	81-51	E	28.25	0.00
4	S	341	R	28.75	0.50
4	S	81-37	R	37.50	1.00
4	S	344	R	34.75	0.03
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	14.50	0.50
2	G	26	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	20.25	1.00
2	G	204	D	19.25	1.50
2	G	228	D	18.00	0.50
2	G	49	D	16.00	1.00
2	G	146	D	DEAD?	-
2	G	238	D	18.50	0.50
2	G	145	D	17.50	1.00
2	G	6	D	21.00	0.00
2	G	64	D	21.00	2.00
2	G	217	B	DEAD	-
2	G	84-18	B	19.00	1.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	10.75	0.50
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	16.50	0.00
4	G	284	Y	15.25	0.00
4	G	192	Y	13.00	0.00
4	G	144	D	DEAD	-
4	G	202	D	23.25	0.00
4	G	137	D	20.00	1.00
4	G	149	D	20.50	0.00
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	16.00	0.50
4	G	31	D	20.00	0.00
4	G	15	B	23.25	0.00
4	G	216	B	14.75	0.00
4	G	215	B	DEAD	-
T	S	100	L	MISSING	-
T	S	39	E	13.75	1.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	DEAD	-
T	S	231	R	22.38	0.08
T	S	322	E	15.25	0.50
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	23.63	2.00
T	G	5	D	22.00	1.00
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	DEAD?	-
T	G	BM2-5	K	5.75	0.00
T	G	1F2-5	K	18.00	1.00
T	G	2F2-5	K	14.50	0.50
T	G	20F	Y	DEAD	-
T	G	7	D	15.88	0.50
T	G	16	D	DEAD	-
T	G	42	Y	DEAD	-
T	G	49	D	DEAD	-
T	G	BM2	K	9.25	0.50
M	S	792	E	16.75	1.50
M	S	230	E	26.25	0.00
M	S	108	E	16.50	0.05
M	S	702	E	19.25	0.25
M	S	110	E	18.50	0.50
M	S	712	E	DEAD	-
M	S	790	E	17.00	0.50
M	S	779	E	25.25	0.00
M	S	753	E	25.00	0.01
M	S	770	R	34.50	0.03
M	G	184	D	24.00	0.50
M	G	118	D	22.25	1.00
M	G	18	D	21.00	0.03
M	G	133	D	DEAD	-
M	G	70	D	20.50	0.50
M	G	20	D	21.75	0.50
M	G	245	D	DEAD	-
M	G	242	D	DEAD	-
M	G	104	D	19.00	0.04
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	17.50	0.00
R	S	274	E	24.25	0.01
R	S	796	E	DEAD	-
R	S	107	E	DEAD	-
R	S	117	E	13.00	2.50
R	G	265	D	DEAD	-
R	G	53	D	DEAD	-
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	DEAD	-
R	G	30	D	14.75	0.00

APPENDIX 5

DATA FOR THE END OF NOVEMBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	LIVE WEIGHT (Kg)	FAECAL O.P.G. (x100)
2	S	307	L	17.50	2.00
2	S	155	L	17.00	2.00
2	S	187	L	16.50	1.00
2	S	112	L	18.00	0.50
2	S	154	L	24.00	1.50
2	S	788	L	22.00	0.01
2	S	291	Y	16.00	0.50
2	S	183	Y	21.50	0.50
2	S	325	Y	26.50	1.00
2	S	141	Y	17.00	0.01
2	S	81-58	E	DEAD	-
2	S	84-10	E	20.00	2.00
2	S	82-23	E	23.00	0.04
2	S	1-261	E	21.00	0.50
2	S	82-27	E	22.00	0.01
2	S	81-68	E	19.50	0.50
2	S	755	R	27.50	0.00
2	S	761	R	32.00	0.11
2	S	284	R	35.00	0.50
2	S	329	R	36.00	0.00
4	S	165	L	15.00	0.50
4	S	161	L	19.00	0.50
4	S	167	L	23.50	0.07
4	S	168	L	22.00	1.50
4	S	106	L	13.00	0.33
4	S	104	L	17.00	2.50
4	S	764	Y	21.25	1.50
4	S	144	Y	16.00	0.50
4	S	218	Y	19.25	0.01
4	S	142	Y	19.00	1.50
4	S	82-14	E	DEAD	-
4	S	81-54	E	22.00	0.50
4	S	81-50	E	23.50	0.05
4	S	82-33	E	22.50	0.43
4	S	81-55	E	24.50	1.00
4	S	81-51	E	24.50	0.00
4	S	341	R	28.00	4.00
4	S	81-37	R	36.00	1.00
4	S	344	R	33.25	2.50
4	S	81-03	R	DEAD	-
2	G	616	K	DEAD	-
2	G	622	K	DEAD	-
2	G	609	K	DEAD	-
2	G	607	K	DEAD	-
2	G	11	Y	13.50	0.00
2	G	28	Y	DEAD	-
2	G	119	Y	DEAD	-
2	G	7	Y	DEAD	-
2	G	22	Y	22.00	0.50
2	G	204	D	16.50	1.50
2	G	228	D	18.75	6.00
2	G	49	D	DEAD?	-
2	G	146	D	DEAD?	-
2	G	238	D	18.75	0.00
2	G	145	D	18.00	1.00
2	G	6	D	18.00	0.50
2	G	64	D	22.50	1.50
2	G	217	B	DEAD	-
2	G	84-18	B	19.50	2.00
2	G	82	B	DEAD	-
4	G	90	K	DEAD	-
4	G	606	K	DEAD	-
4	G	630	K	DEAD	-
4	G	608	K	10.50	2.00
4	G	8	Y	DEAD	-
4	G	183	Y	DEAD	-
4	G	240	Y	17.50	0.50
4	G	284	Y	14.00	1.50
4	G	192	Y	13.00	6.00
4	G	144	D	DEAD	-
4	G	202	D	22.00	0.50
4	G	137	D	21.75	0.01
4	G	149	D	19.75	0.01
4	G	292	D	DEAD	-
4	G	220	D	DEAD	-
4	G	111	D	13.75	5.00
4	G	31	D	22.00	0.50
4	G	15	B	23.00	1.00
4	G	216	B	16.50	0.50
4	G	215	B	DEAD	-
T	S	100	L	MISSING	-
T	S	39	E	13.75	1.00
T	S	81-12	E	DEAD	-
T	S	81-24	E	MISSING	-
T	S	55	L	DEAD	-
T	S	231	R	22.38	2.00
T	S	322	E	16.00	0.50
T	S	335	E	DEAD	-
T	S	221	L	DEAD	-
T	S	81-41	E	DEAD	-
T	S	81-57	E	DEAD	-
T	S	300	E	DEAD	-
T	G	3	D	DEAD	-
T	G	4	D	23.00	0.07
T	G	5	D	22.13	1.00
T	G	8	D	DEAD	-
T	G	FEM	Y	DEAD	-
T	G	6-12	K	DEAD?	-
T	G	BM2-5	K	6.63	0.01
T	G	1F2-5	K	18.75	0.50
T	G	2F2-5	K	15.63	0.50
T	G	20F	Y	DEAD	-
T	G	7	D	16.88	3.00
T	G	16	D	DEAD	-
T	G	42	Y	DEAD	-
T	G	49	D	DEAD	-
T	G	BM2	K	13.50	2.00
M	S	792	E	15.00	0.50
M	S	230	E	22.25	5.00
M	S	108	E	15.00	0.03
M	S	702	E	17.50	5.50
M	S	110	E	15.50	1.00
M	S	712	E	DEAD	-
M	S	790	E	15.50	0.11
M	S	779	E	23.00	1.50
M	S	753	E	19.50	0.00
M	S	770	R	33.50	2.50
M	G	184	D	20.00	0.50
M	G	118	D	22.75	1.00
M	G	18	D	18.00	1.50
M	G	133	D	DEAD	-
M	G	70	D	18.50	0.50
M	G	20	D	19.50	0.00
M	G	245	D	DEAD	-
M	G	242	D	DEAD	-
M	G	104	D	19.25	0.07
M	G	81	B	DEAD	-
R	S	787	E	DEAD	-
R	S	797	E	DEAD	-
R	S	789	E	DEAD	-
R	S	81-59	E	DEAD	-
R	S	282	E	17.75	1.00
R	S	274	E	25.00	0.00
R	S	796	E	DEAD	-
R	S	107	E	DEAD	-
R	S	117	E	13.25	6.50
R	G	265	D	DEAD	-
R	G	53	D	DEAD	-
R	G	117	D	DEAD	-
R	G	27	D	DEAD	-
R	G	293	D	DEAD	-
R	G	30	D	15.50	0.00

APPENDIX 5

DATA FOR THE BEGINNING OF DECEMBER 1986

EXP - GRP	TYPE	ANIMAL NUMBER	AGE - SEX	PCV %	TOTAL PROTEIN (g/dl)	ALBUMEN (g/dl)	GLOBULIN (g/dl)
2	S	307	L	28.5	8.60	3.45	5.15
2	S	155	L	29.0	9.50	3.55	5.95
2	S	157	L	29.0	8.80	3.40	5.40
2	S	112	L	31.0	8.18	3.55	4.63
2	S	154	L	28.5	8.95	3.70	5.25
2	S	788	L	29.8	8.95	4.10	4.85
2	S	291	Y	30.8	9.00	3.00	6.00
2	S	183	Y	33.0	9.35	4.70	4.65
2	S	325	Y	29.5	8.80	3.40	5.40
2	S	141	Y	27.0	7.50	3.40	4.10
2	S	81-58	E	DEAD	-	-	-
2	S	84-10	E	28.0	8.75	2.75	6.00
2	S	82-23	E	31.0	9.25	3.55	5.70
2	S	1-261	E	24.5	9.50	3.40	6.10
2	S	82-27	E	30.0	7.70	3.25	4.45
2	S	81-68	E	26.5	11.00	3.25	7.75
2	S	755	R	32.0	8.33	3.55	4.78
2	S	761	R	30.5	9.35	2.60	6.75
2	S	284	R	26.0	9.25	3.40	5.85
2	S	329	R	30.0	7.63	4.30	3.33
4	S	165	L	33.0	8.33	3.70	4.63
4	S	161	L	28.8	8.05	3.40	4.65
4	S	167	L	33.5	9.15	4.10	5.05
4	S	168	L	39.0	10.50	4.43	6.07
4	S	106	L	26.5	8.33	3.30	5.03
4	S	104	L	26.8	7.90	3.15	4.75
4	S	764	Y	28.0	9.15	3.70	5.45
4	S	144	Y	28.0	7.63	3.65	3.98
4	S	219	Y	30.5	8.60	3.65	4.95
4	S	142	Y	27.0	8.60	4.20	4.40
4	S	82-14	E	DEAD	-	-	-
4	S	81-54	E	27.0	10.05	3.10	6.95
4	S	81-50	E	22.5	8.90	3.10	5.80
4	S	82-33	E	29.0	10.05	3.95	6.10
4	S	81-55	E	30.5	8.18	3.45	4.73
4	S	81-51	E	23.0	8.33	4.05	4.28
4	S	341	R	28.5	9.75	3.45	6.30
4	S	81-37	R	30.0	8.33	4.30	4.03
4	S	344	R	27.0	9.50	3.45	6.05
4	S	81-03	R	DEAD	-	-	-
2	G	616	K	DEAD	-	-	-
2	G	622	K	DEAD	-	-	-
2	G	609	K	DEAD	-	-	-
2	G	607	K	DEAD	-	-	-
2	G	11	Y	34.5	9.50	3.10	6.40
2	G	26	Y	DEAD	-	-	-
2	G	119	Y	DEAD	-	-	-
2	G	7	Y	DEAD	-	-	-
2	G	22	Y	35.0	8.90	3.35	5.55
2	G	204	D	28.0	8.95	3.25	5.70
2	G	228	D	27.5	10.05	2.58	7.47
2	G	49	D	DEAD	-	-	-
2	G	146	D	DEAD	-	-	-
2	G	238	D	32.0	8.80	2.78	6.02
2	G	145	D	36.5	8.80	2.53	6.27
2	G	6	D	32.5	7.63	3.25	4.38
2	G	64	D	32.5	8.00	3.30	4.70
2	G	217	B	DEAD	-	-	-
2	G	84-18	B	29.5	8.33	2.90	5.43
2	G	82	B	DEAD	-	-	-
4	G	90	K	DEAD	-	-	-
4	G	606	K	DEAD	-	-	-
4	G	630	K	DEAD	-	-	-
4	G	608	K	31.0	8.75	3.18	5.57
4	G	8	Y	DEAD	-	-	-
4	G	183	Y	DEAD	-	-	-
4	G	240	Y	28.5	9.80	3.25	6.55
4	G	284	Y	29.8	10.35	2.65	7.70
4	G	192	Y	27.0	8.33	2.98	5.35
4	G	144	D	DEAD	-	-	-
4	G	202	D	30.0	9.30	3.25	6.05
4	G	137	D	30.5	8.60	3.50	5.10
4	G	149	D	34.5	10.35	2.85	7.50
4	G	292	D	DEAD	-	-	-
4	G	220	D	DEAD	-	-	-
4	G	111	D	34.0	8.90	2.78	6.12
4	G	31	D	36.5	10.90	3.30	7.60
4	G	15	B	27.8	10.35	3.55	6.80
4	G	216	B	27.0	12.30	3.05	9.25
4	G	215	B	DEAD	-	-	-
M	S	792	E	40.1	10.00	4.20	5.80
M	S	230	E	32.3	9.30	3.80	5.50
M	S	108	E	31.8	8.70	3.88	4.82
M	S	702	E	37.5	9.35	4.30	5.05
M	S	110	E	36.5	10.55	4.30	6.25
M	S	712	E	DEAD	-	-	-
M	S	790	E	37.0	9.50	4.50	5.00
M	S	779	E	36.0	8.33	4.35	3.98
M	S	753	E	38.0	10.00	3.70	6.30
M	S	770	R	35.0	9.35	3.70	5.65
M	G	184	D	30.0	5.18	2.53	5.66
M	G	118	D	33.0	9.00	3.70	5.30
M	G	18	D	26.8	8.60	2.73	5.87
M	G	133	D	DEAD	-	-	-
M	G	70	D	28.8	10.05	3.18	6.87
M	G	20	D	26.8	10.35	2.58	7.77
M	G	245	D	DEAD	-	-	-
M	G	242	D	DEAD	-	-	-
M	G	104	D	29.5	9.50	2.85	6.70
M	G	81	B	DEAD	-	-	-
R	S	787	E	DEAD	-	-	-
R	S	797	E	DEAD	-	-	-
R	S	789	E	DEAD	-	-	-
R	S	81-59	E	DEAD	-	-	-
R	S	282	E	25.0	8.60	3.95	4.65
R	S	274	E	32.0	8.75	3.45	5.30
R	S	796	E	DEAD	-	-	-
R	S	107	E	DEAD	-	-	-
R	S	117	E	23.3	8.60	3.10	5.50
R	G	265	D	DEAD	-	-	-
R	G	53	D	DEAD	-	-	-
R	G	117	D	DEAD	-	-	-
R	G	27	D	DEAD	-	-	-
R	G	293	D	DEAD	-	-	-
R	G	30	D	23.5	9.25	2.30	6.95

Appendix 6 Infective larval contamination of sheep pastures at IRZ, Mankon Station (1985-86)

Period	No. of L_3 infective larvae per kg DM							
	2-dose anthelmintic				4-dose anthelmintic			
	Haem.	*Trich.*	*Oesoph.*	All	*Haem.*	*Trich.*	*Oesoph.*	All
Mid Dec. 85	51	51	17	119	384	217	67	668
Mid Jan.	0	0	0	0	35	12	0	47
Mid Feb.	0	0	0	0	10	0	0	10
Mid March	0	14	0	14	29	0	0	29
Mid April	19	0	0	19	16	0	0	16
Mid May	41	20	0	61	137	28	0	165
Mid June	25	0	0	25	22	0	0	22
Mid July	30	0	0	30	0	0	0	0
Mid Aug.	62	0	0	62	644	0	0	644
Mid Sept.	138	0	23	161	25	0	0	25
Mid Oct.	21	0	0	21	0	0	0	0
Mid Nov. 86	18	0	0	18	0	0	0	0

Appendix 7 Infective larval contamination of goat pastures at IRZ, Mankon Station (1985-86)

Period	No. of L_3 infective larvae per kg DM							
	2-dose anthelmintic				4-dose anthelmintic			
	Haem.	Trich.	Oesoph.	All	Haem.	Trich.	Oesoph.	All
Mid Dec. 85	55	28	0	83	45	15	0	60
Mid Jan.	11	11	0	22	73	0	0	73
Mid Feb.	0	11	0	11	13	39	0	52
Mid March	0	0	0	0	16	0	0	16
Mid April	114	0	0	114	0	0	0	0
Mid May	492	92	62	646	636	58	0	694
Mid June	175	25	0	200	1123	192	0	1315
Mid July	52	0	0	52	28	0	0	28
Mid Aug.	153	0	0	153	2850	52	0	2902
Mid Sept.	422	0	0	422	54	0	0	54
Mid Oct.	28	0	0	28	17	0	0	17
Mid Nov. 86	0	0	0	0	0	0	0	0

Appendix 8 Infective larval contamination of pastures grazed by sheep and goats on mixed grazing at IRZ Mankon Station (1985–1986)

Period	No. of L3 infective larvae per kg DM			
	Haem.	*Trich.*	*Oesoph.*	All
Mid Dec. 1985	0	0	0	0
Mid April	89	18	0	107
Mid May	40	0	0	40
Mid June	169	0	0	169
Mid July	44	22	0	66
Mid August	43	0	0	43
Mid Sept.	24	0	0	24
Mid Oct.	123	41	0	164
Mid Nov. 1986	0	0	0	0

Appendix 9 Infective larval contamination of traditionally managed sheep and goat pastures (1985–1986)

Period	No. of L3 infective larvae per kg DM			
	Haem.	*Trich.*	*Oesoph.*	All
End Nov. 85	15	0	0	15
End Dec. 85	49	12	0	61
End Jan. 86	10	0	0	10
End Feb. 86	17	0	0	17
End March 86	0	0	0	0
End April 86	0	0	24	24
End May 86	2646	106	18	2770
End June 86	21	21	0	42
End July 86	23	0	0	23
End Aug. 86	56	0	0	56
End Sept. 86	282	0	0	282
End Oct. 86	0	0	0	0
End Nov. 86	0	0	0	0

Appendix 10 Post-mortem worm counts on sheep and goats under five management systems in the North West Province of Cameroon (1985/86)

Month	Date	Type of animal	Group	Animal No.	Parasite count H. cont	T. axei	T. col	B. trig	S. pap	O. col	T. ovis	Moniezia	Meta-cestode	Oestrus ovis
Dec. 85	Dec 13	Goat	TVM	42	80	50	950	10	-	3	-			
	Dec 31	Sheep	TVM	81-41	770	800	3500	50	-	820	-	-	-	
Jan. 86	Jan 1	Sheep	TS	787	20	-	17500	-	-	1	-	-		
	Jan 3	Sheep	TS	789	1160	350	12300	-	-	-	-	-	-	
	Jan 6	Sheep	TS	81-59	300	150	11750	-	-	-	-	-	-	
	Jan 9	Goat	2-dose	616	430	150	2000	-	-	-	-	-	-	
	Jan 10	Sheep	TVM	81-12	150	500	3450	10	-	660	-	-	+	
	Jan 13	Sheep	4-dose	82-14	Ischaemia; acute haemorrhagic gastro-enteritis									
	Jan 18	Sheep	TVM	300	1040	-	10750	900	-	900	-	5	+	
	Jan 21	Goat	4-dose	183	361	321	8450	-	-	-	-	-	-	
	Jan 23	Sheep	2-dose	81-58	1590	751	10500	-	-	-	-	5	-	
	Jan 23	Sheep	TVM	221	1180	103	3250	480	-	950	-	4	+	
	Jan 27	Sheep	TS	797	1910	952	34350	-	-	-	2	-	+	
	Jan 27	Goat	4-dose	220	630	21	13500	-	-	-	-	-	+	
	Jan 28	Goat	4-dose	90	570	2	3250	-	-	-	-	-	-	
	Jan 28	Goat	2-dose	609	931	68	8200	-	-	-	-	1	-	
	Jan 29	Sheep	Mixed	712	861	122	6600	-	-	-	-	-	+	
	Jan 30	Goat	TS	27	1290	200	8300	-	-	-	-	-	-	
Feb. 86	Feb 13	Goat	2-dose	622	790	-	600	-	-	-	-	-	+	+
	Feb 17	Goat	Mixed	81	950	-	3100	-	-	-	-	-	-	4
	Feb 20	Sheep	TS	798	200	-	-	-	-	-	-	-	-	-
Mar. 86	Mar 8	Goat	4-dose	292	10	-	350	-	-	-	-	-	-	-
	Mar 18	Goat	2-dose	82	2680	100	7950	-	-	-	-	-	-	7
	Mar 19	Goat	4-dose	606*	Streaks of blood along trachea, perforation left rib cage						15			
	Mar 22	Sheep	4-dose	81-03*	Intestine haemorrhagic and empty									
	Mar 26	Goat	Mixed	133	890	-	17000	-	-	-	-	2	-	17
Apr. 86	Apr 6	Goat	2-dose	26	2040	100	5750	-	-	-	-	-	+	25
	Apr 6	Goat	2-dose	7	920	50	2400	-	-	-	-	-	-	40
	Apr 8	Goat	2-dose	607	1120	400	1550	-	-	-	-	-	-	19
	Apr 8	Goat	2-dose	119	1880	200	1300	-	-	-	-	-	-	27
	Apr 16	Goat	4-dose	141	1740	-	800	-	-	-	-	-	-	64
May. 86	May 6	Goat	4-dose	8	10	-	750	-	-	-	-	-	-	13
	May 19	Sheep	TVM	26	100	-	1250	130	-	40	-	-	-	2
	May 22	Sheep	TVM	335	100	-	600	10	-	450	-	-	-	6
	May 27	Goat	4-dose	215	1140	-	500	-	-	-	-	4	-	7
Jun. 86	Jun 1	Goat	4-dose	630	1410	-	300	-	-	9	1	4	-	21
	Jun 5	Goat	TVM	20	4850	1100	4400	-	100	165	5	-	-	25
	Jun 8	Goat	TS	117	930	-	25000	-	-	12	8	1	-	29
	Jun 13	Goat	Mixed	242	2650	-	4600	-	-	1	1	5	-	22
	Jun 27	Goat	TVM	16	720	350	1400	-	-	70	1	-	-	4
July 86	Jul 1	Goat	2-dose	217	460	100	350	-	-	35	50	-	-	1
	Jul 6	Goat	TVM	49	620	650	1100	10	-	-	-	-	-	-
	Jul 8	Sheep	TVM	55	190	500	7100	210	-	90	-	-	-	-
	Jul 26	Goat	Mixed	245	560	-	1300	-	-	1	12	1	+	31
Sept 86	Sep 9	Goat	TS	293	8650	-	6550	-	-	93	-	-	-	6
Oct. 86	Oct 5	Sheep	TS	107	110	-	21000	-	-	267	57	-	+	
	Oct 12	Goat	2-dose	146	4390	-	800	-	-	62	-	-	-	
	Oct 30	Goat	TS	53	5900	100	23700	-	-	122	3	-	-	
	Oct 31	Goat	TS	265	Treated with albendazole one day before death PCV = <9; Hb conc.: 1.2g; RBC: 2.08 x 10; WBC: 15.4 x 10									
Nov. 86	Nov 21	Goat	2-dose	49	550	-	250	-	-	5	-	-	-	6

*Animals treated with levamisole on 14/3/86; 4-dose = 4-dose anthelmintic regime; 2-dose = 2-dose anthelmintic regime; Mixed = Mixed grazing of sheep and goats; TS = On-station traditional management; TVM = Traditional village management; H. cont = H. contortus; T.col = T. colubriformis; B. trig = B. trigonocephalum; S. pap = S. papillosus; O. col = O. columbianum.

Appendix 11 Changes in packed cell volume and haemoglobin concentration of European lambs and kids infected with a single dose of 10,000 L_3 of the ES strain of *H. contortus*

Parameter	Experimental group	Animal No.	Pre-infection	3 days after infection	7 days after infection	10 days after infection	14 days after infection	17 days after infection
PCV (%)	Infected lambs	EL6	24.0	23.5				
		EL7	37.2	37.5	38.2			
		EL8	36.5	36.2	36.0	35.7	30.0	
		EL9	29.5	28.7	29.5	28.0	25.2	20.7
	Control lamb	EL15	35.2	34.0	33.2	33.5	33.5	32.0
	Infected kids	EK2	30.5	27.5				
		EK4	24.2	21.5	22.5			
		EK3	23.5	21.5	21.5	22.2	22.2	
		EK5	24.5	23.0	23.7	23.0	23.5	21.5
	Control kid	EK1	21.7	20.5	21.0	20.5		
Hb. conc. (g per 100 ml bld)	Infected lambs	EL6	7.8	7.2				
		EL7	11.6	13.7	11.6			
		EL8	11.2	10.7	11.2	11.1	9.2	
		EL9	10.1	9.1	9.5	9.8	8.2	6.9
	Control lamb	EL15	12.4	10.3	10.7	12.2	10.8	11.6
	Infected kids	EK2	9.5	8.7				
		EK4	8.2	7.2	10.5			
		EK3	7.6	7.2	7.8	8.2	8.4	
		EK5	8.4	7.9	8.5	7.7	7.4	7.8
	Control kid	EK1	7.6	6.3	6.9	6.7		

Appendix 12.1a Changes in haematological values of indigenous lambs infected with a single dose of 10,000 L_3 of the LG strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	135	30.5	30.5					
	146	26.5	26.5	23.5				
	136	30.0	30.5	31.0	30.5	31.0		
	1460	31.0	30.0	32.0	29.0	26.8	22.3	17.8
	138	28.6	30.6	31.7	28.5	26.8	26.8	22.5
Hb conc.	135	10.05	11.16					
g per	146	5.94	8.33	7.67				
100 ml	136	9.65	10.54	10.67	10.05	11.16		
bld	1460	13.35	11.57	12.33	10.29	9.87	7.71	4.46
	138	9.47	10.80	9.42	9.07	8.99	9.92	8.89
RBC	135	10.56	10.57					
($x10^6$)	146	9.29	9.44	8.96				
per cmm	136	9.14	8.11	9.68	9.71	10.00		
	1460	8.74	10.21	10.05	8.77	7.83	7.01	5.13
	138	10.38	11.58	13.05	11.32	11.20	10.18	9.96
WBC	135	8.75	8.60					
($x10^3$)	146	17.20	9.70	10.35				
per cmm	136	6.30	8.60	8.05	10.50	9.40		
	1460	7.80	10.10	11.60	8.85	9.55	9.25	13.75
	138	9.55	10.95	11.55	11.00	10.80	12.35	11.85

Appendix 12.1b Changes in haematological values of indigenous kids infected with a single dose of 10,000 L_3 of the LG strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	254	25.9	27.6					
	295	21.0	22.0	21.5				
	289	16.0	17.5	17.5	16.5	16.0		
	186	29.0	23.5	27.5	21.0	15.3	15.0	13.5
	237	28.8	27.8	28.8	25.5	25.8	23.0	22.8
Hb conc.	254	8.20	9.55					
(g per	295	8.90	6.63	6.48				
100 ml	289	5.16	5.20	5.59	4.89	4.97		
bld)	186	9.78	9.25	7.81	7.05	5.65	4.86	4.05
	237	8.40	8.67	8.39	8.00	8.07	8.33	7.38
RBC	254	13.75	14.09					
($x10^6$)	295	12.49	12.25	13.53				
per cmm	289	10.58	10.60	10.63	10.43	10.96		
	186	14.05	13.06	12.38	11.83	10.89	7.57	6.66
	237	12.52	12.93	12.98	13.24	13.16	11.37	11.58
WBC	254	22.25	16.60					
($x10^3$)	295	16.60	13.30	17.75				
per cmm	289	20.25	17.70	17.60	22.35	19.70		
	186	12.45	14.70	10.70	10.25	9.25	12.95	12.85
	237	10.95	14.45	10.80	10.65	10.65	11.90	13.30

Appendix 12.2a Changes in haematological values of indigenous lambs infected with a single dose of 10,000 L_3 of the LS strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	168	35.5	24.8					
	169	36.5	38.3	35.5				
	172	24.8	27.0	26.5	27.5			
	170	33.5	29.5	32.0	28.0	23.5		
	6	31.0	30.5	29.5	32.0	29.5	29.0	24.5
Hb conc.	168	11.61	10.06					
(g per	169	12.70	12.44	11.88				
100 ml	172	8.97	10.51	9.83	9.32			
bld)	170	12.02	10.20	10.67	8.94	9.84		
	6	10.67	12.68	11.18	11.72	10.16	13.33	6.76
($x10^6$)	169	12.05	12.73	11.92				
per cmm	172	8.10	8.62	8.95	9.22			
	170	11.08	9.80	10.34	9.70	8.45		
	6	11.47	10.04	10.18	9.16	9.99	9.49	7.68
WBC_3	168	12.60	10.30					
($x10^3$)	169	14.50	12.90	16.15				
per cmm	172	6.35	7.40	7.40	9.75			
	170	11.05	13.65	16.60	13.65	12.70		
	6	10.90	15.95	12.70	13.75	11.70	11.20	11.60

Appendix 12.2b Changes in haematological values of indigenous kids infected with a single dose of 10,000 L_3 of the LS strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	152	15.8	14.3					
	150	26.8	26.25	27.5				
	153	23.5	22.0	19.0	18.5			
	151	26.0	24.5	24.0	21.0	19.8		
	142	26.0	23.5	24.0	21.0	20.0	17.0	13.0
Hb conc. (g per 100 ml bld)	152	4.78	4.89					
	150	10.18	8.14	8.98				
	153	6.93	7.59	6.36	6.68			
	151	12.70	9.73	8.42	7.27	7.06		
	142	8.78	9.08	7.53	7.89	6.28	5.10	2.37
RBC ($x10^6$) per cmm	152	7.82	7.36					
	150	11.07	10.11	10.09				
	153	13.89	10.99	12.21	12.48			
	151	13.35	12.20	10.36	10.64	9.90		
	142	15.90	13.46	15.31	12.35	10.81	11.73	7.51
WBC ($x10^3$) per cmm	152	23.55	19.90					
	150	18.55	16.70	21.85				
	153	13.40	11.45	13.25	12.60			
	151	11.25	10.30	11.75	13.05	11.80		
	142	16.35	15.85	11.80	11.0	15.75	11.40	10.60

Appendix 12.3a Changes in haematological values of indigenous lambs infected with a single dose of 10,000 L_3 of the ES strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	147	32.0	26.5					
	746	25.0	27.5	28.0				
	721	30.0	27.5	31.5	29.8			
	742	35.0	31.0	33.5	32.0	27.5		
	722	27.0	29.8	25.8	27.8	28.0	25.0	18.8
Hb conc.	147	9.24	8.75					
(g per	746	7.93	10.58	9.55				
100 ml	721	9.89	10.06	9.70	9.44			
bld)	742	9.76	10.27	10.49	10.26	8.47		
	722	9.44	9.93	9.82	9.03	9.38	7.20	6.35
RBC	147	9.43	10.20					
($x10^6$)	746	9.13	8.48	9.22				
per cmm	721	9.87	9.20	10.43	9.50			
	742	11.88	10.09	10.91	10.39	10.52		
	722	10.04	10.25	11.18	9.08	9.48	8.20	7.11
WBC	147	14.15	15.45					
($x10^3$)	746	7.90	6.75	6.70				
per cmm	721	10.55	10.00	10.65	18.00			
	742	7.90	12.40	10.55	11.75	13.05		
	722	13.65	10.00	10.75	11.20	13.70	11.60	10.55

Appendix 12.3b Changes in haematological values of indigenous kids infected with a single dose of 10,000 L3 of the ES strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
PCV (%)	283	28.0	31.0					
	246	31.0	32.5	29.5				
	84-44	30.5	30.0	28.8	26.0			
	53	27.8	24.8	25.0	25.0	21.0		
	278	24.0	22.0	21.8	23.0	20.0	23.3	19.3
Hb conc.	283	8.55	8.89					
g per	246	9.37	9.29	9.44				
100 ml	84-44	9.24	8.26	8.92	7.38			
bld	53	7.93	7.74	7.61	7.38	6.59		
	278	7.08	6.90	6.72	6.19	5.79	6.53	5.82
RBC	283	13.70	13.76					
($x10^6$)	246	13.84	14.89	16.49				
per cmm	84-44	17.65	12.83	14.90	13.57			
	53	10.76	9.13	11.41	11.55	10.94		
	278	12.83	11.62	9.91	10.48	8.29	10.61	9.77
WBC	283	14.20	16.15					
($x10^3$)	246	15.10	16.65	16.45				
per cmm	84-44	21.35	20.70	18.70	21.15			
	53	15.25	17.70	20.25	18.05	12.25		
	278	17.25	13.95	9.00	15.70	17.40	16.00	16.85

Appendix 12.4 Changes in haematological values of uninfected indigenous lambs and kids (controls) bled at 3 day intervals

Parameter	Species	Initial value	Haematological values after: 3 days	6 days	9 days	12 days	15 days	18 days
PCV (%)	Lamb	25.8	28.0	27.0	28.5	26.0	25.5	24.8
	Kid	25.0	25.0	27.0	26.5	24.0	23.8	25.5
Hb conc. (g per 100 ml bld)	Lamb	9.79	10.01	9.82	9.56	10.20	9.07	9.96
	Kid	9.08	8.89	8.10	9.74	8.39	8.62	9.62
RBC $x10^6$ per cmm	Lamb	8.44	9.92	8.04	9.99	9.53	9.70	8.07
	Kid	14.58	14.40	13.95	13.36	13.47	13.63	13.45
WBC $x10^3$ per cmm	Lamb	11.70	7.25	7.00	7.85	12.15	11.75	9.85
	Kid	12.50	12.65	14.45	10.75	8.70	10.45	14.60

Appendix 13.1a Changes in serum biochemical values of indigenous lambs infected with a single dose of 10,000 L_3 of the LG strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
Protein (g/dl)	135	7.40	8.13					
	146	9.50	9.80	9.35				
	136	8.13	7.85	7.30	7.30	7.40		
	1460	8.95	7.85	7.70	7.15	8.35	7.63	7.63
	138	6.65	7.08	5.95	6.53	6.40	5.95	5.83
Albumin (g/dl)	135	4.3	3.95					
	146	4.05	4.10	3.95				
	136	4.10	4.35	4.05	4.43	4.30		
	1460	4.30	3.95	4.10	3.55	3.70	3.15	2.70
	138	4.30	4.60	4.10	4.05	3.95	4.10	3.65
Globulin (g/dl)	135	3.1	4.18					
	146	5.45	5.70	5.40				
	136	4.03	3.50	3.25	2.87	3.10		
	1460	4.65	3.90	3.60	3.60	4.65	4.48	4.93
	138	2.35	2.48	1.85	2.48	2.45	1.85	2.18
Serum pepsinogen (x1000 mU of tyrosine	135	0.695	1.321					
	146	0.626	0.973	1.738				
	136	0.487	0.348	2.155	0.765	1.251		
	1460	0.348	0.487	2.363	1.182	0.834	1.321	0.765
	138	0.104	0.417	1.877	1.043	2.363	2.850	2.363

Appendix 13.1b Changes in serum biochemical values of indigenous kids infected with a single dose of 10,000 L_3 of the LG strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
Protein	254	8.80	8.35					
(g/dl)	295	8.80	8.70	9.25				
	289	10.60	9.80	9.70	10.30	10.10		
	186	9.50	9.30	8.90	8.33	8.25	7.55	7.63
	237	8.90	8.60	7.75	7.20	8.90	7.90	7.63
Albumin	254	3.50	3.55					
(g/dl)	295	3.25	3.30	3.18				
	289	2.78	2.58	2.58	2.78	2.90		
	186	3.05	3.25	3.45	3.50	2.85	2.85	2.73
	237	3.63	4.00	3.10	2.78	3.45	3.25	3.50
Globulin	254	5.30	4.80					
(g/dl)	295	5.55	5.40	6.07				
	289	7.82	7.22	7.12	7.52	7.20		
	186	6.45	6.05	5.45	4.83	5.40	4.70	4.90
	237	5.27	4.60	4.65	4.42	5.45	4.65	4.13
Serum	254	0	0.417					
pepsinogen	295	0.174	1.877	1.112				
(x1000	289	0.556	0.2085	0.278	0.556	0.695		
mU	186	0.174	0	0.765	0.765	0.765	0.695	0
tyrosine)	237	0.056	0.556	1.946	1.738	2.78	1.112	0.834

Appendix 13.2a Changes in serum biochemical values of indigenous lambs infected with a single dose of 10,000 L_3 of the LS strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
Protein (g/dl)	168	8.33	8.80					
	169	8.80	8.80	8.18				
	172	7.40	7.15	8.13	8.18			
	170	7.85	7.95	8.13	8.13	7.70		
	6	8.60	9.0	8.60	8.33	8.05	7.40	7.20
Albumin (g/dl)	168	4.68	4.30					
	169	2.73	3.05	2.98				
	172	3.55	4.43	4.05	4.10			
	170	4.75	4.50	4.43	4.75	3.65		
	6	4.70	4.75	4.75	4.10	4.05	4.50	4.30
Globulin (g/dl)	168	3.65	4.50					
	169	6.07	5.75	5.20				
	172	3.85	2.72	4.08	4.08			
	170	3.10	3.45	3.70	3.38	4.05		
	6	3.90	4.25	3.85	4.23	4.00	2.90	2.90
Serum pepsinogen (x1000 mU of tyrosine)	168	0	0.348					
	169	0	0.056	2.433				
	172	0.695	0.417	0.695	0.348			
	170	0.487	0.487	1.599	1.112	0.765		
	6	0.104	0.487	1.738	0.904	1.321	0.834	1.807

Appendix 13.2b Changes in serum biochemical values of indigenous kids infected with a single dose of 10,000 L_3 of the LS strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
Protein (g/dl)	152	10.35	9.15					
	150	8.90	8.05	8.90				
	153	8.90	9.50	8.33	9.35			
	151	8.18	8.90	8.60	7.63	9.15		
	142	8.35	9.5	8.75	8.05	8.35	6.65	7.35
Albumin (g/dl)	152	3.45	2.78					
	150	3.25	3.50	2.78				
	153	3.35	3.75	3.45	3.25			
	151	2.98	2.90	2.40	2.73	3.05		
	142	3.55	3.35	3.35	3.10	3.50	2.30	2.73
Globulin (g/dl)	152	6.90	6.37					
	150	5.65	4.55	6.12				
	153	5.55	5.75	4.88	6.10			
	151	5.20	6.00	6.20	4.90	6.10		
	142	4.80	6.15	5.40	4.95	4.85	4.35	4.62
Serum pepsinogen (x1000 mU of tyrosine)	152	0.209	0.174					
	150	0.209	0.973	1.599				
	153	0.626	0.174	1.460	1.321			
	151	0.348	0.104	1.39	1.599	1.39		
	142	0.209	0.209	1.182	1.112	0.904	0.765	0

Appendix 13.3a Changes in serum biochemical values of indigenous lambs infected with a single dose of 10,000 L3 of the ES strain of *H. contortus*

Parameter	Lamb No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
	147	6.85	7.48					
Protein	746	8.18	7.48	8.18				
(g/dl)	721	7.48	7.58	7.75	7.35			
	742	7.63	7.75	7.70	7.08	6.65		
	722	6.65	7.63	7.75	7.50	6.93	7.20	6.65
Albumin	147	3.80	4.10					
(g/dl)	746	4.43	3.95	3.80				
	721	4.60	4.30	3.95	3.65			
	742	4.30	4.05	3.95	3.95	3.70		
	722	4.43	4.43	4.60	4.30	4.30	3.95	4.43
Globulin	147	3.05	3.38					
(g/dl)	746	3.75	3.53	4.38				
	721	2.88	3.28	3.80	3.70			
	742	3.33	3.70	3.25	3.13	2.95		
	722	2.22	3.20	3.15	3.20	2.63	3.25	2.22
Serum	147	0	0.174					
pepsinogen	746	0.973	0.209	0.278				
(x1000	721	0.417	0.209	0.348	0.626			
mU of	742	0.834	0.174	1.599	1.946	2.016		
tyrosine)	722	0.209	0	0.765	0.626	0.348	0.209	1.877

Appendix 13.3b Changes in serum biochemical values of indigenous kids infected with a single dose of 10,000 L3 of the ES strain of *H. contortus*

Parameter	Kid No.	Pre-infection	3 days after infection	6 days after infection	9 days after infection	12 days after infection	15 days after infection	18 days after infection
Total Protein (g/dl)	283	6.60	7.75					
	246	7.63	7.35	7.35				
	84-44	8.60	8.05	7.90	9.15			
	53	7.08	7.20	7.08	7.48	6.80		
	278	8.33	9.00	8.90	9.30	8.90	9.15	8.18
Albumin (g/dl)	283	3.50	3.50					
	246	3.35	3.25	3.35				
	84-44	3.75	3.63	3.30	3.70			
	53	3.45	3.25	3.25	2.98	3.10		
	278	3.63	3.83	3.35	3.90	3.50	3.55	3.55
Globulin (g/dl)	283	3.10	4.25					
	246	4.28	4.10	4.0				
	84-44	4.85	4.42	4.60	5.45			
	53	3.63	3.95	3.83	4.50	3.70		
	278	4.70	5.17	5.55	5.40	5.40	5.60	4.63
Serum pepsinogen (x1000 mU of tyrosine)	283	0	0.209					
	246	0.626	1.112	1.877				
	84-44	0.487	0.348	0.056	1.112			
	53	0.348	0.417	1.529	1.599	1.877		
	278	0.209	0.209	0.556	1.043	0.904	5.699	0

Appendix 13.4 Changes in serum biochemical values of uninfected indigenous lambs and kids bled at 3 day intervals

Parameter	Species	Initial value	Serum biochemical values after: 3 days	6 days	9 days	12 days	15 days	18 days
Total protein (g/dl)	Lamb	8.80	8.25	7.95	8.35	8.60	8.60	8.18
	Kid	9.50	9.50	8.90	9.50	9.0	9.75	9.35
Albumin (g/dl)	Lamb	2.90	3.70	4.10	3.95	4.68	4.35	4.60
	Kid	3.63	3.10	3.35	3.30	3.25	3.30	2.98
Globulin (g/dl)	Lamb	5.90	4.55	3.85	4.40	3.92	4.25	3.58
	Kid	5.87	6.40	5.50	6.20	5.75	6.45	6.37
Serum pepsinogen (x 1000 mU tyrosine)	Lamb	0.417	0.695	0.209	0.487	0.626	0.104	0.209
	Kid	0.487	0.174	0.626	0.765	0.348	0.765	0

Appendix 14 WBC differential counts in lambs infected with escalating doses of *H. contortus* (ES strain) - Mean values and percentage of total count

Parameters	Pre-infection	Period after initial infection 1st week	2nd week	3rd week	4th week	5th week	7th week	8th week
Infected lambs:-								
Neutrophils %	33.0	23.7	32.2	29.5	30.6	36.7	25.7	32.2
No.	3125	2336	3451	2677	2615	3277	1625	2317
Lymphocytes %	62.0	68.1	62.5	64.9	64.1	59.7	70.2	66.0
No.	6078	6711	6224	5773	5218	5187	4596	4681
Monocytes %	4.2	7.4	3.5	2.7	3.9	3.0	3.2	1.0
No.	427	684	361	262	334	254	212	78
Eosinophils %	0.7	0.7	0.7	2.9	1.4	0.5	0.7	0.7
No.	70	70	65	227	109	32	55	49
Control lambs:-								
Neutrophils %	26.0	17.5	17.5	17.5	21.5	25.5	28.0	23.0
No.	2782	1771	1668	1722	2274	2163	2398	2019
Lymphocytes %	72.5	77.0	78.5	80.5	72.2	73.5	70.5	76.0
No.	7633	7800	7455	7927	7419	6228	6584	6421
Monocytes %	1.0	4.5	3.0	2.0	2.5	1.0	1.5	0.5
No.	106	453	283	203	252	85	168	39
Eosinophils %	0.5	1.0	1.0	-	3.7	-	-	0.5
No.	55	102	95	-	372	-	-	46

Appendix 15 WBC differential counts in kids infected with escalating doses of *H. contortus* (ES strain) - Mean values and percentage of total count

Parameters	Pre-infection	Period after initial infection: 1st week	2nd week	3rd week	4th week	5th week	7th week	8th week
Infected kids:-								
Neutrophils %	30.7	37.7	33.0	24.5	25.7	35.0	38.7	29.7
No.	3695	4744	4328	2881	2752	3841	3799	2896
Lymphocytes %	64.2	59.7	62.5	69.6	68.4	61.7	59.2	67.5
No.	7742	8001	8020	8786	7154	6671	5768	6539
Monocytes %	4.0	0.7	4.2	3.2	3.1	1.7	1.0	1.4
No.	412	118	445	325	357	196	90	112
Eosinophils %	0.7	1.4	0.2	2.6	2.5	1.2	1.0	1.4
No.	83	166	32	259	206	113	81	128
Basophils %	-	0.4	-	-	0.2	-	-	-
No.	-	34	-	-	19	-	-	-
Control kids:-								
Neutrophils %	39.0	42.5	36.5	35.0	25.0	26.5	24.5	31.0
No.	5126	5420	3937	3925	2208	2329	2408	4050
Lymphocytes %	56.0	53.0	59.0	61.0	70.5	71.0	72.5	60.0
No.	5912	6092	6142	5958	6068	6186	6857	8094
Monocytes %	5.0	4.2	1.7	2.5	3.0	1.5	1.5	2.0
No.	639	415	187	266	269	129	139	268
Eosinophils %	-	0.2	2.7	1.5	1.5	1.0	1.5	7.0
No.	-	25	285	127	132	83	148	963

Appendix 16 Mean weekly liveweights in lambs and kids infected with 200 L_3 daily doses of two strains of *H. contortus* at Mankon, Cameroon

Period (weeks)	Mean liveweights (kg)					
	Mankon goat-adapted strain		Mankon sheep-adapted strain		Uninfected controls	
	Lambs	Kids	Lambs	Kids	Lambs	Kids
0	9.1	6.5	10.2	6.1	10.7	7.1
1	9.7	6.7	11.1	6.4	10.9	7.4
2	9.7	6.1	10.7	6.1	11.0	7.1
3	9.7	6.6	10.7	6.1	10.9	7.3
4	9.8	6.5	10.8	6.1	11.1	7.3
5	10.0	6.4	11.0	6.1	11.0	7.3
6	9.7	6.5	10.9	6.1	11.3	7.4
7	10.4	6.8	11.1	6.2	11.7	7.4
8	10.5	6.9	11.4	6.4	11.6	7.4
9	10.6	6.7	11.3	6.4	12.0	7.4
10	10.6	6.7	11.7	6.4	12.0	7.9
11	10.6	6.8	11.8	6.4	12.1	7.8
12	10.8	6.7	11.9	6.7	12.3	8.0
13	10.9	6.9	11.8	6.8	12.6	8.1
14	11.2	6.9	12.1	6.9	12.6	8.2
15	11.0	6.8	12.1	6.6	12.4	8.1
16	11.1	6.9	12.0	6.9	12.5	8.0
17	11.3	6.7	12.2	6.9	12.6	8.1
18	11.5	6.9	12.4	6.9	12.7	8.3
19	11.6	7.0	12.7	7.1	13.0	8.4
20	12.1	7.2	13.2	7.1	13.1	8.8

WEEKS SINCE INF	HOST	STRAIN OF H. cont.	PCV (%)	Hb (g%)	RBC (Mil)	WBC (Thou)	Alb (g/dl)	Glob (g/dl)	Prot (g/dl)
Pre	Lambs	LG	30.0	10.7	10.1	8.8	4.4	3.4	7.8
Pre	Lambs	LS	27.3	9.9	9.2	11.0	4.6	4.3	8.9
Pre	Lambs	Cont	30.8	10.4	9.9	12.0	4.2	3.9	8.1
Pre	Kids	LG	27.0	8.6	13.1	23.7	3.9	5.3	9.2
Pre	Kids	LS	26.5	8.9	12.8	23.4	3.2	6.1	9.3
Pre	Kids	Cont	29.8	10.9	14.8	18.6	3.3	4.6	7.9
1	Lambs	LG	29.0	10.8	10.3	9.7	4.5	2.9	7.4
1	Lambs	LS	27.2	9.8	9.7	9.4	4.4	4.1	8.5
1	Lambs	Cont	29.3	9.5	9.5	13.7	3.9	3.6	7.5
1	Kids	LG	24.5	7.6	11.2	22.2	3.4	4.0	7.4
1	Kids	LS	22.8	8.3	10.7	19.8	3.4	5.3	8.7
1	Kids	Cont	27.3	10.0	14.7	18.7	3.6	4.7	8.3
2	Lambs	LG	31.2	11.5	10.3	9.8	4.7	3.4	8.1
2	Lambs	LS	29.0	10.4	9.4	8.1	4.3	3.9	8.2
2	Lambs	Cont	29.2	9.4	9.9	12.3	4.2	3.5	7.7
2	Kids	LG	25.8	8.7	12.3	21.5	3.6	5.1	8.7
2	Kids	LS	25.0	8.4	11.8	22.3	3.1	6.2	9.3
2	Kids	Cont	26.8	9.8	14.8	17.9	3.5	4.9	8.4
3	Lambs	LG	28.7	10.0	9.6	9.9	4.8	2.9	7.7
3	Lambs	LS	27.8	9.1	9.2	12.3	4.2	4.7	8.9
3	Lambs	Cont	30.2	10.6	10.2	11.4	4.2	2.9	7.1
3	Kids	LG	23.0	7.6	12.0	16.2	3.6	4.0	7.6
3	Kids	LS	23.0	7.6	11.0	18.9	3.2	6.7	9.9
3	Kids	Cont	25.3	8.7	12.6	21.6	3.3	5.4	8.8
4	Lambs	LG	27.7	11.0	9.7	10.8	4.5	3.4	7.9
4	Lambs	LS	27.7	10.1	9.1	12.5	4.3	3.9	8.2
4	Lambs	Cont	30.3	10.4	10.2	12.9	4.3	4.0	8.3
4	Kids	LG	24.8	8.3	10.6	14.2	3.2	5.5	8.7
4	Kids	LS	20.8	6.6	8.9	22.2	3.1	5.3	8.4
4	Kids	Cont	27.5	10.9	12.9	19.8	3.4	5.2	8.6
5	Lambs	LG	30.0	11.1	10.7	11.1	4.3	3.0	7.3
5	Lambs	LS	28.8	9.7	9.5	10.9	4.2	4.0	8.2
5	Lambs	Cont	31.8	11.0	10.2	13.2	4.7	3.1	7.8
5	Kids	LG	24.5	7.4	11.7	17.7	3.4	5.1	8.5
5	Kids	LS	20.3	8.0	10.0	22.1	3.1	5.8	8.9
5	Kids	Cont	26.3	9.5	12.6	23.6	3.9	4.9	8.8
6	Lambs	LG	30.7	10.2	10.1	12.8	4.2	3.6	7.8
6	Lambs	LS	29.5	9.9	9.1	11.3	4.4	3.7	8.1
6	Lambs	Cont	33.0	11.1	10.9	12.1	4.5	3.3	7.8
6	Kids	LG	26.3	9.2	10.0	13.6	3.5	4.8	8.3
6	Kids	LS	19.5	5.7	9.7	17.9	3.0	5.8	8.8
6	Kids	Cont	25.8	8.9	14.3	24.1	3.7	4.6	8.3
7	Lambs	LG	30.5	9.5	10.4	15.5	4.5	3.4	7.9
7	Lambs	LS	30.8	10.6	9.7	8.3	4.8	3.4	8.2
7	Lambs	Cont	34.0	11.4	11.4	15.2	4.8	3.0	7.8
7	Kids	LG	24.5	7.4	10.1	22.5	3.8	4.4	8.2
7	Kids	LS	19.5	6.2	8.0	22.6	3.0	6.2	9.2
7	Kids	Cont	27.3	10.2	14.2	21.5	4.1	4.7	8.8
8	Lambs	LG	31.3	11.7	10.4	10.4	4.4	3.1	7.5
8	Lambs	LS	29.5	9.8	10.1	11.0	4.5	3.6	8.1
8	Lambs	Cont	37.2	13.6	11.7	9.3	4.9	3.2	8.1
8	Kids	LG	24.0	7.5	9.8	23.5	3.4	4.5	7.9
8	Kids	LS	20.2	8.5	9.0	21.6	3.1	4.6	7.7
8	Kids	Cont	28.0	9.2	14.7	15.7	3.6	5.2	8.8
9	Lambs	LG	33.0	11.2	10.1	11.6	4.7	3.2	7.9
9	Lambs	LS	31.3	10.9	10.1	12.1	4.5	4.0	8.5
9	Lambs	Cont	33.7	11.7	10.6	11.3	4.8	2.7	7.5
9	Kids	LG	25.8	7.2	10.7	20.7	3.7	5.1	8.8
9	Kids	LS	21.8	7.1	9.3	21.6	3.5	5.6	9.1
9	Kids	Cont	28.0	8.5	13.1	17.5	3.7	4.8	8.5
10	Lambs	LG	32.5	11.5	10.0	9.4	4.5	3.5	8.0
10	Lambs	LS	33.2	11.4	10.0	9.2	4.6	4.1	8.7
10	Lambs	Cont	35.5	10.4	10.4	10.7	4.5	3.3	7.8
10	Kids	LG	23.2	7.1	10.9	13.9	4.1	4.5	8.6
10	Kids	LS	23.5	6.5	10.6	19.7	3.3	5.3	8.6
10	Kids	Cont	29.5	9.8	13.4	15.7	3.0	6.1	9.1
11	Lambs	LG	30.7	10.5	10.0	10.4	5.0	3.3	8.3
11	Lambs	LS	31.3	9.2	9.8	10.2	4.5	3.7	8.2
11	Lambs	Cont	33.0	10.3	10.0	8.5	4.8	3.0	7.8
11	Kids	LG	21.5	5.8	10.2	12.0	3.8	4.8	8.6
11	Kids	LS	21.5	6.5	10.6	19.8	3.2	5.2	8.4
11	Kids	Cont	30.3	8.0	13.2	18.2	4.1	5.0	9.1
12	Lambs	LG	31.0	10.7	9.8	10.2	4.2	4.0	8.2
12	Lambs	LS	25.8	10.2	9.4	10.7	3.9	4.2	8.1
12	Lambs	Cont	34.6	10.8	10.1	10.1	4.2	3.5	7.7
12	Kids	LG	23.5	7.7	11.2	12.9	3.5	4.9	8.4
12	Kids	LS	22.0	7.4	9.5	21.4	3.0	5.5	8.5
12	Kids	Cont	28.8	9.7	14.0	19.1	3.5	4.6	8.1
13	Lambs	LG	32.0	10.7	9.1	10.9	4.3	3.9	8.2
13	Lambs	LS	29.0	10.2	9.5	10.2	4.8	3.9	8.7
13	Lambs	Cont	32.5	9.4	8.9	12.2	4.6	3.7	8.3
13	Kids	LG	23.8	7.4	10.9	14.6	3.9	4.7	8.6
13	Kids	LS	25.3	7.1	10.0	16.2	3.5	5.3	8.8
13	Kids	Cont	30.8	9.7	12.1	23.2	3.7	4.5	8.2
14	Lambs	LG	28.0	9.0	8.8	9.4	4.1	4.3	8.4
14	Lambs	LS	28.3	9.5	9.0	9.6	4.2	4.2	8.4
14	Lambs	Cont	32.4	10.2	9.8	7.9	4.2	4.1	8.3
14	Kids	LG	24.0	7.6	10.0	19.2	3.3	5.9	9.2
14	Kids	LS	19.8	6.3	8.4	17.8	3.2	6.7	9.9
14	Kids	Cont	31.0	9.2	14.0	24.9	3.6	5.3	8.9
15	Lambs	LG	31.3	9.7	8.9	7.6	4.0	5.0	9.0
15	Lambs	LS	29.8	9.5	9.0	9.9	3.7	4.2	7.9
15	Lambs	Cont	33.2	11.4	10.2	7.9	4.4	4.1	8.5
15	Kids	LG	22.7	6.5	10.5	15.5	3.2	5.9	9.1
15	Kids	LS	19.3	5.9	8.0	15.5	3.6	6.1	9.7
15	Kids	Cont	29.7	9.4	14.4	25.1	3.6	5.4	9.0
16	Lambs	LG	32.5	11.6	9.9	10.4	4.2	4.2	8.4
16	Lambs	LS	26.3	10.7	9.2	10.3	3.6	4.8	8.4
16	Lambs	Cont	35.2	12.3	10.4	7.4	4.5	3.7	8.2
16	Kids	LG	23.7	9.9	10.8	16.7	3.5	5.1	8.6
16	Kids	LS	22.8	6.6	8.7	17.2	3.3	6.1	9.4
16	Kids	Cont	27.0	9.3	13.5	30.6	3.2	5.4	8.6
17	Lambs	LG	30.5	11.3	9.5	8.9	4.0	4.2	8.2
17	Lambs	LS	28.8	11.1	10.1	9.0	3.7	5.4	9.1
17	Lambs	Cont	33.8	13.0	10.4	9.3	4.2	3.8	8.0
17	Kids	LG	22.9	7.7	10.4	12.6	3.6	5.0	8.6
17	Kids	LS	22.4	8.2	9.5	17.9	3.3	6.1	9.4
17	Kids	Cont	26.5	9.5	13.7	18.4	3.5	4.5	8.0
18	Lambs	LG	30.3	11.2	8.9	8.7	4.1	4.7	8.8
18	Lambs	LS	27.9	10.2	9.3	9.8	3.7	4.8	8.5
18	Lambs	Cont	34.8	12.4	10.0	10.5	4.4	3.9	8.3
18	Kids	LG	24.3	8.7	10.8	12.5	3.0	7.0	10.0
18	Kids	LS	24.2	9.6	9.1	19.0	3.3	5.7	9.0
18	Kids	Cont	28.3	9.3	15.0	15.4	3.1	5.1	8.2
19	Lambs	LG	30.5	11.0	9.2	6.7	4.3	4.0	8.3
19	Lambs	LS	28.5	10.3	9.5	7.9	3.9	4.8	8.7
19	Lambs	Cont	34.9	12.0	9.9	8.4	4.4	3.4	7.8
19	Kids	LG	24.3	8.3	11.5	16.0	3.3	5.0	8.3
19	Kids	LS	23.5	8.1	10.5	21.7	3.2	6.3	9.5
19	Kids	Cont	28.8	10.4	14.6	22.3	3.2	5.4	8.6
20	Lambs	LG	31.5	11.2	9.1	6.5	4.2	4.8	9.0
20	Lambs	LS	29.2	10.0	9.7	13.4	4.4	4.1	8.5
20	Lambs	Cont	34.8	12.3	10.1	10.2	4.0	4.5	8.5
20	Kids	LG	26.5	8.5	11.6	17.4	3.4	5.7	9.1
20	Kids	LS	26.0	9.9	10.9	27.4	3.5	5.9	9.4
20	Kids	Cont	27.3	11.3	13.4	23.5	3.4	5.0	8.4

Appendix 17b Mean haematological values of uninfected lambs and kids (controls) bled weekly for 20 weeks

Period	Mean haematological values PCV (%)		HB conc. (g %)		RBC ($x10^6$) per cmm		WBC ($x\ 10^3$) per cmm	
	Lambs	Kids	Lambs	Kids	Lambs	Kids	Lambs	Kids
Initial value	30.8	29.8	10.4	10.9	9.9	14.8	12.1	18.7
1st week	29.3	27.3	9.5	10.0	9.5	14.7	13.7	18.7
2nd week	29.2	26.8	9.4	9.8	9.9	14.8	12.3	17.9
3rd week	30.2	25.3	10.6	8.7	10.2	12.6	11.4	21.7
4th week	30.3	27.5	10.4	10.9	10.2	12.9	12.9	19.8
5th week	31.8	26.3	11.0	9.6	10.2	12.6	13.3	23.6
6th week	33.0	25.8	11.1	8.9	10.9	14.3	12.1	24.1
7th week	34.0	27.3	11.4	10.2	11.4	14.2	15.2	21.5
8th week	37.2	28.0	13.6	9.2	11.7	14.7	9.3	15.7
9th week	33.7	28.0	11.8	8.5	10.6	13.1	11.4	17.5
10th week	35.5	29.5	10.4	9.8	10.4	13.4	10.8	15.7
11th week	33.0	30.3	10.3	8.0	10.0	13.2	8.5	18.3
12th week	34.6	28.8	10.8	9.7	10.1	14.0	10.1	19.1
13th week	32.5	30.8	9.4	9.7	8.9	12.1	12.2	23.2
14th week	32.4	31.0	10.2	9.3	9.8	14.0	7.9	25.0
15th week	33.2	29.7	11.4	9.4	10.2	14.4	7.9	25.1
16th week	35.2	27.0	12.3	9.3	10.4	13.5	7.5	30.6
17th week	33.8	26.5	13.0	9.5	10.4	13.7	9.3	18.4
18th week	34.8	28.3	12.4	9.3	10.0	15.0	10.6	15.4
19th week	34.9	28.8	12.0	10.4	9.9	14.6	8.4	22.4
20th week	34.8	27.3	12.3	11.3	10.2	13.4	10.2	23.5

Appendix 17c Mean serum total protein and protein fraction values of uninfectd lambs and kids (controls) bled weekly for 20 weeks

Period	Mean serum biochemical values					
	Albumin (g/dl)		Globulin (g/dl)		Total protein (g/dl)	
	Lambs	Kids	Lambs	Kids	Lambs	Kids
Initial value	4.2	3.3	3.9	4.6	8.1	7.9
1st week	3.9	3.6	3.6	4.7	7.5	8.3
2nd week	4.2	3.5	3.6	4.9	7.8	8.4
3rd week	4.2	3.3	2.9	5.4	7.1	8.7
4th week	4.3	3.4	4.0	5.2	8.3	8.6
5th week	4.7	3.9	3.1	4.9	7.8	8.8
6th week	4.6	3.7	3.3	4.6	7.9	8.3
7th week	4.8	4.1	3.0	4.7	7.8	8.8
8th week	4.9	3.6	3.2	5.2	8.1	8.8
9th week	4.8	3.7	2.7	4.8	7.5	8.5
10th week	4.5	3.0	3.4	6.1	7.9	9.1
11th week	4.8	4.2	3.0	5.0	7.8	9.2
12th week	4.3	3.5	3.5	4.6	7.8	8.1
13th week	4.6	3.7	3.7	4.5	8.3	8.2
14th week	4.2	3.6	4.2	5.3	8.4	8.9
15th week	4.4	3.7	4.1	5.4	8.5	9.1
16th week	4.6	3.2	3.7	5.4	8.3	8.6
17th week	4.3	3.5	3.8	4.5	8.1	8.0
18th week	4.4	3.1	3.9	5.1	8.3	8.2
19th week	4.4	3.2	3.4	5.4	7.8	8.6
20th week	4.0	3.4	4.6	5.0	8.6	8.4

Appendix 18 Changes in serum pepsinogen concentration in lambs and kids on daily infections with 200 L_3 of two strains of *H. contortus* in Mankon, Cameroon.

Period (weeks)	Serum pepsinogen concentration (x 1000 mU tyrosine)					
	Lambs			Kids		
	LG strain	LS strain	Uninfected controls	LG strain	LS strain	Uninfected controls
0	0.186	0.417	0.383	0.487	0.487	0.383
1	0.278	0.116	0.220	0.487	0.435	0.296
2	0.672	0.626	0.603	1.217	0.765	0.591
3	2.108	1.043	0.417	1.391	0.209	0.105
4	0.974	0.765	0.510	0.557	2.242	0.348
5	0.730	1.182	0.441	2.468	1.008	0.765
6	1.321	0.718	0.406	0.800	1.634	0.261
7	0.695	0.973	0.232	1.078	0.383	0.244
8	0.695	0.881	0.255	1.634	0.800	0.452
9	0.996	0.834	0.603	1.217	1.078	0.522
10	0.950	0.684	0.580	1.321	0.800	0.487
11	1.112	1.112	0.255	1.217	0.661	0.244
12	0.753	0.857	0.336	1.217	0.973	0.296
13	0.881	0.464	0.325	1.286	0.973	0.139
14	0.765	0.626	0.325	0.973	1.043	0.244
15	0.950	0.348	0.324	1.356	0.383	0.209
16	1.136	0.510	0.232	1.321	0.904	0.209
17	0.603	1.367	0.475	1.460	1.321	0.313
18	1.529	1.784	0.186	1.390	0.418	0.383
19	1.379	0.649	0.274	1.877	1.078	0.383
20	0.556	0.719	0.174	1.703	0.869	0.661

Trop. Anim. Hlth Prod. (1987) 19, 237–244

PRODUCTIVITY OF SHEEP AND GOATS UNDER THREE MANAGEMENT SYSTEMS AT BAMENDA, CAMEROON

K. J. N. NDAMUKONG[1], M. M. H. SEWELL[2,4], and M. F. ASANJI[3]

[1] *Institute of Animal Research, Mankon Station, PO Box, 125, Bamenda, Cameroon;* [2] *Centre for Tropical Veterinary Medicine, University of Edinburgh, UK;* [3] *Advanced Teacher's College (ENS), University of Yaounde annex Bambili, Cameroon*

SUMMARY

The productivity of sheep and goats was examined under three management systems. A regime by which each animal received five doses of fenbendazole in a year gave similar results in terms of survival and liveweight gain to monthly dosing. Sheep kept by traditional methods without anthelmintic treatment survived and grew less well than goats. In contrast goats grew better and produced more young under traditional management although they were in general lighter than sheep.

INTRODUCTION

Sheep and goat production in Bamenda, North West Province of Cameroon is mainly in the hands of subsistence farmers who keep them for their meat and for socio-economic reasons. The animals are either herded all year round (mainly true for sheep), left on free range, either throughout the year or during the non-cropping season or tethered, either throughout the year or during the cropping season. Farmers who can afford to keep the animals in numbers ranging from 50 to 300 or more usually have them herded or kept on free range all year round. However, due to limitation on grazing land and financial resources the majority of farmers keep only small numbers ranging from one to ten. At Government livestock and research stations including Mankon, larger numbers (300–500 sheep and/or goats) are kept and managed semi-intensively.

Previous necropsy findings had suggested that helminthiasis, especially haemonchosis and trichostrogylosis, is a major disease problem in small ruminants on the Animal Research Station at Mankon near Bamenda. Studies by FAO (1966) and Schillhorn van Veen (1981) have also shown that helminthiasis is one of the most important diseases of goats and sheep in Nigeria and that haemonchosis plays a major role (Fabiyi, 1973; Kuil, 1973; Akerejola, Schillhorn van Veen and Njoku, 1979). Schillhorn van Veen (1982) characterised the humid zone goat as a "walking helminthic zoo" on account of its multitude of parasites and their vectors. It therefore seemed appropriate to assess the value of controlling this disease in sheep and goats in the N.W. Province of Cameroon.

MATERIALS AND METHODS

The study was carried out from November 1984 to October 1985 at the Animal Research Station at Mankon and in collaboration with four sheep and goat farmers at Batibo. The research station is located at an altitude of about 1,000 m in N.W. Cameroon. The village of Batibo lies some 50 km to the south

[4] Reprint correspondence: Dr M. M. H. Sewell, CTVM, Easter Bush, Roslin, Midlothian EH25 9RG, Scotland.

TABLE I

Age and sex distribution of experimental sheep and goats kept under three different management regimes in N.W. Province of Cameroon

Site	Management group	Sheep Adult male	Sheep Adult female	Sheep Lamb	Goats Adult male	Goats Adult female	Goats Kids
Mankon	Standard	5	11	5	1	9	10
	Reduced anthelmintic	5	11	5	2	8	10
Batibo	Traditional farmer	1	9	2	1	11	6
	A	0	0	0	1	5	1
	B	0	3	1	0	2	1
	C	0	4	0	0	2	3
	D	1	2	1	0	2	1

of Bamenda at an altitude of about 900 m; daily rainfall and air temperatures were read from equipment located at the research station.

There were three treatment groups for each species (Table I):

1. Standard Mankon regime in which the animals are kept in paddocks on improved grazing with some supplementary feeding and monthly anthelmintic treatment with fenbendazole (Panacur, Hoechst) at 7·5mg/kg body weight.
2. Reduced anthelmintic regime which was similar to the Standard Mankon regime except that fenbendazole at 7·5 mg/kg body weight was only given five times in the year, in the first weeks of November, December, March, July and September.
3. Traditional village management with animals kept in small flocks with little or no supplementary food and no anthelmintic treatment.

The animals under the standard management and reduced anthelmintic regimes were located at the research station while the traditionally managed animals were with local farmers at Batibo.

The logistics behind the times chosen for the treatments in the Reduced anthelmintic regime closely correspond to those suggested by Fabiyi (1973). Thus the first two treatments in November and December were intended to reduce the dry season burdens at a period when good pasture is becoming scarce so that malnutrition is likely to occur and aggravate the effect of even light worm burdens. These treatments should also have rid the animals of parasites with long development periods within the host such as *Oesophagostomum* and *Bunostomum*, which may be implicated in mortalities occurring during the first half of the dry season. The third treatment in the first week of March was intended to eliminate any remaining worm burdens in the animals and reduce the rate of pasture contamination when the environment becomes relatively favourable for development of helminth infective larvae. This should postpone the peak of helminth infections and delay any clinical outbreak of helminthiasis involving *Haemonchus* and *Trichostrongylus*. The fourth and fifth treatments were given in the first weeks of July and September respectively to eliminate any burdens that

had built up after the March treatment and further delay or prevent clinical outbreaks of disease.

The two groups of 21 sheep each at Mankon (Table I) were set-stocked on approximately half hectare paddocks while the two groups of 20 goats were each kept on two one-quarter hectare paddocks, each paddock being grazed in alternate months as the herbage was eaten off. The pastures at Mankon, which consist of partially improved pastures of *Stylosanthes* sp., *Branchiaria ruziziensis, Melinis minutiflora, Pennisetum purpureum, Hyparrhenia* sp. and *Imperata contortus*, had been grazed by animals of the general stock before being utilised for this study. The animals were housed overnight in aluminium roofed cement block houses on slatted floors and were not usually sent out before 9·00 a.m. to allow the dew to evaporate from the pastures. Each morning before being sent out for grazing the animals were given about 0·25 kg of a mixture of cottonseed cake, rice bran, corn and calcium diphosphate containing 14 to 16% protein. In the dry season they also received elephant grass and guatemala grass from hay-racks. Salt and water were provided *ad lib.*

The traditionally managed animals belonged to four farmers (Table I). The owners of the animals with which the study commenced withdrew their co-operation in January 1986 so that most of the data from this particular group refers to the period after that time. Housing for these animals consisted of an aluminium roofed slatted floor enclosure constructed of eucalyptus logs for the floor and a combination of raffia bamboos, tree fern and sticks for the walls. The sheep and goats were usually tethered during the cropping season but left on free range between August and February once the crops had matured and were being harvested. In addition to green forage (mainly *Melinis minutiflora, Pennisetum purpureum, Hyparrhenia* sp., *Aspelia* sp. and *Imperata contortus*) and browse, which was abundantly available during most of the year, the animals also fed on harvest residues.

At necropsy the rumen, abomasum, small intestine, caecum and large intestine were separately examined for helminth parasites. The washings from the abomasum and small intestine—and also from the large intestine when it was observed to contain a large number of parasites—were made up to 10 litres with water and the numbers of nematodes present estimated from 10% and 2% aliquots. The abomasal mucosa was removed using the edge of a glass slide, suspended in 200 ml of 1% pepsin in 5% HCl and incubated overnight at 37°C (Herlich, 1956, Hunter and MacKenzie, 1982).

RESULTS

The temperature and rainfall data are summarised in Fig. 1. The period between December and mid-March, when rainfall was either very scanty or nil, is referred to as the dry season. At this time the ground becomes hard and most of the grass withers, the only fresh vegetation being found along banks of streams and rivers. The wet season extended from mid-March to November. The rainfall was usually heavier during the day than at night except in October. Monthly mean minimum temperatures were above 15°C except between November and February.

The reduced anthelmintic regime gave similar results in terms of survival (Table II) and live weight gain (Table III) to the standard Mankon regime. This applied to both sheep and goats and to young stock and adults alike. However,

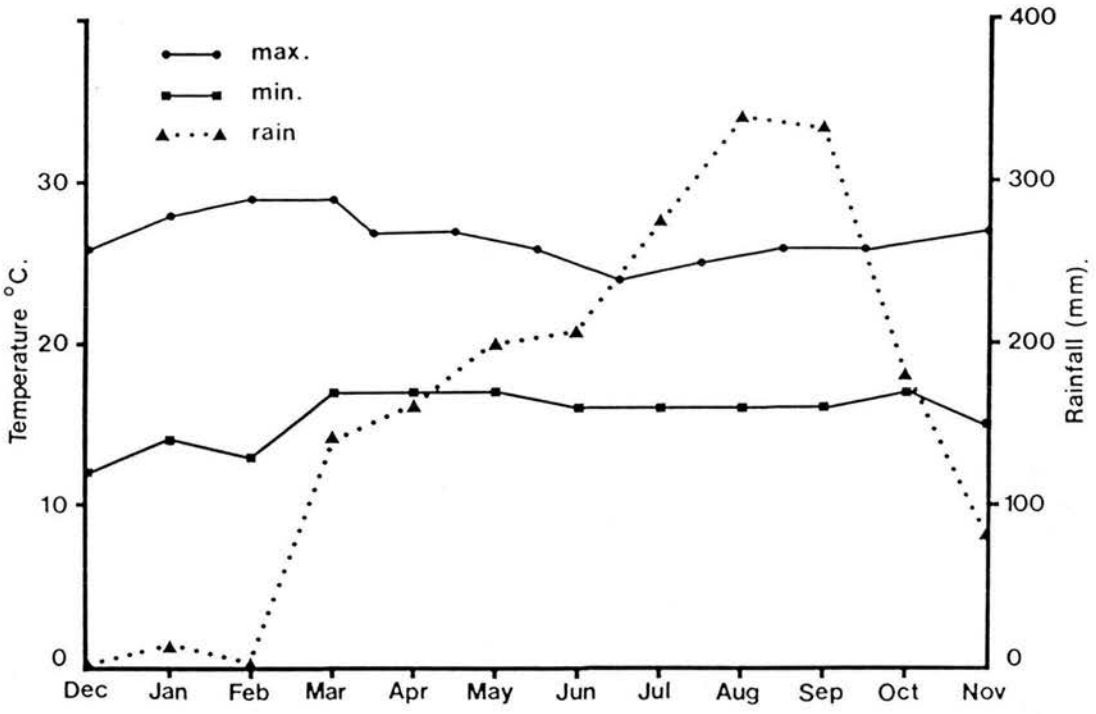


FIG. 1. Meterological data for Mankon, 1984–85. Mean monthly maximum temperature, mean monthly minimum temperature and mean monthly rainfall.

the goats at Mankon grew less well than the sheep and although they performed slightly better on the standard regime than on the reduced regime this difference was not significant.

In contrast sheep kept by traditional local methods survived significantly ($P < 0{\cdot}01$) less well than goats (Table III) and also grew ($P < 0{\cdot}05$) more slowly than sheep kept under either management system at Mankon (Table III). Conversely goats grew better ($P < 0{\cdot}005$) and produced more young when kept by the traditional local methods than they did at Mankon although they were in general individually lighter than sheep.

Post-mortem examination of animals that died during the experiment revealed

TABLE II

Mortality in sheep and goats kept under three different management systems in N.W. Province of Cameroon

Management system	Animals that died/Animals in group (percentage mortality) Sheep	Goats
Standard Mankon regime	4/20 (20%)	2/20 (10%)
Reduced anthelmintic regime	2/21 (10%)	3/20 (15%)
Traditional village management	9/13 (69%)	1/18 (7%)

TABLE III

Mean initial liveweights and mean weight gains in sheep and goats in the N.W. Province of Cameroon in 1984–1985

Type of animal	Age and sex	Type of management	Number of animals	Initial liveweight (kg)	Liveweight gain (kg) Jan–Oct	Nov–Oct
Sheep	Lambs	S	4	7·7	10·4	15·4
		R	5	7·5	11·9	15·6
		T	2	15·0[1]	—	1·6
	Adult females	S	9	21.3	2·8	6·4
		R	9	21.1	2·2	5·8
		T	1	21·5[1]	−5·0	—
	Adult males	S	3	22·1	11·6	15·1
		R	5	22·4	14·6	15·6
		T	1	19·0[1]	−0·7	—
Goats	Kids	S	8	10·9	2·7	3·1
		R	8	11·4	1·1	1·5
		T	5	8·9	2·8	6·1
	Adult females	S	9	20·3	0·2	−0·1
		R	7	21·7	0·5	−2·0
		T	7	20·9	2·1	4·1
	Adult males	S	1	18·0	3·2	4·0
		R	2	17·0	3·1	2·1
		T	1	16·2	1·7	1·5

[1] Mean initial weight in January—other initial weights in November. S = Standard regime. R = Reduced anthelmintic regime. T = Traditional management.

that most of them contained large numbers of nematodes (Table IV). Most of the deaths, especially those of sheep, occurred amongst animals under traditional management. There were higher worm counts in animals that died during the wet season than in those that died during the dry months. Thus *H. contortus* numbers were raised from early in the wet season to October. The highest *Haemonchus* burden from a single animal at autopsy (>5,000 worms) was from a goat while sheep did not appear to tolerate more than 2,500 adult worms.

The seasonal trend of *Trichostrongylus* infection was similar to that of *Haemonchus* with somewhat higher burdens in sheep than in goats. *O. columbianum* and *B. trigonocephalum* were only recovered from animals that died during the wet season. *T. ovis* was only occasionally present and then only during the wet season. *M. expansa* showed no seasonal trend. Intermediate stages of dog tapeworms were occasionally seen both in sheep and goats.

DISCUSSION

The climatic and other environmental conditions around Bamenda are suitable for the development of the extra-host stages of trichostrongyles throughout most of the year (Williamson and Payne, 1978). The high ambient temperatures in Bamenda with rainfall for about eight months of the year increase the survival rate of these stages. The presence of tall herbage on the pastures provides relatively favourable conditions for the survival and development of the eggs and larvae even during most of the dry season.

TABLE IV

Post-mortem worm counts on sheep and goats kept under three different management systems in the N.W. Province of Cameroon

Period (month)	Type of animal	Group	Animal no.	Mean worm counts								
				H. contortus	*T. axei.*	*T. col.*	*B. trigono.*	*S. papill.*	*O. columb.*	*T. ovis*	*Moniezia*	Metacestode
Jan.	Goat	S	201	700	—	700	—	—	—	—	5	–
April	Sheep	S	17	360	10	26,850	—	—	—	—	—	–
	Sheep	R	81-64	4,140	1,750	135,000	—	—	—	—	—	+
	Goat	S	214	—	—	600	—	—	—	—	—	–
	Goat	R	213	150	—	300	—	—	—	—	—	+
July	Sheep	T	45	4,300	3,700	18,250	—	—	—	—	—	+
	Sheep	T	230	1,710	200	12,500	50	—	44	—	10	–
	Sheep	T	234	10	2,600	13,700	250	—	12	—	—	–
	Sheep	T	46	100	1,800	28,350	210	—	636	2	2	–
	Sheep	T	235	1,090	700	4,800	800	250	48	—	2	–
Aug.	Sheep	S	8,409	—	—	—	—	—	—	—	—	–
	Sheep	T	30	1,650	900	10,050	320	50	307	7	1	–
	Goat	T	18	5,850	2,900	1,650	—	—	251	30	—	–
Sept.	Sheep	R	81-52	1,040	100	34,750	—	—	11	—	—	–
	Sheep	S	82-26	50	220	10	—	—	—	—	—	–
	Sheep	T	53	2,360	2,560	35,000	420	—	39	1	3	–
	Sheep[1]	S	307	2,080	—	1,550	—	—	—	—	—	+
Oct.	Goat	R	127	5,720	—	26,600	—	—	—	—	—	–

[1] Culled. S = Standard regime R = Reduced anthelmintic regime. T = Traditional management.

T. col.—T. colubriformis *B. trigono.—B. trigonocephalum*

S. papill—S. papillosus *O. columb.—O. columbianum.*

The results at Mankon suggest that a strategic anthelmintic regime involving four to five doses of anthelmintic a year can give similar results in terms of productivity to the previously used standard regime of monthly dosing. This applies to all stock both young and adults. Since it is probable that only a single dose is needed at the onset of the dry season this would allow a saving of eight doses of anthelmintic per animal per year.

The goats at Mankon gained considerably less weight than sheep and from May to November the faecal egg counts from sheep were consistently lower than those from goats. This did not occur with the traditionally managed animals where goats gained considerably more weight than the sheep and the faecal egg counts from sheep remained consistently higher than those from the goats. The poor growth rate in the goats at Mankon may be related to the fact that they were forced to graze and largely denied the browsed fodder which constitutes a major part of their natural diet. Schillhorn van Veen (1982) suggested that browsing behaviour reduces the chances of acquiring pasture-transmitted parasite infections and there is good evidence that goats usually have a lower infection rate with trichostrongyles than sheep (Andersen and Christofferson, 1973). However, the unavoidable rotation of the goats on their smaller paddocks may have led to them grazing pasture which was more heavily contaminated with infective larvae than the set-stocked sheep paddocks.

The poor performance of the traditionally managed sheep may indicate that, where they are under some nutritional stress because they are either less inclined to browse or less able to utilise the browse, they are more susceptible to helminth infections than goats. The absence of treatment may then have resulted in the high mortality in the sheep.

The rationale for the reduced anthelmintic regime at Mankon appears to have worked well despite the sub-optimal management of grazing pastures. It would appear from the present study that set-stocking about 40 animals per hectare paddock of partially improved pastures would be more effective than rotational grazing in control of worm infections. Animals should preferably be moved each year to a fresh pasture that has not been grazed throughout one dry season and the pastures they have previously used should be left ungrazed over the next dry season for the infective larvae to die off.

ACKNOWLEDGEMENTS

We are grateful to Dr R. Fomunyam, Chief of Station at Mankon for her support and acknowledge the hard work of Sam Chi and Acha Daniel in caring for the experimental animals. We are especially grateful to Messrs G. Akoh, J. Mbah, L. Ndamukong and G. Mbah the farmers at Batibo who allowed access to their animals. Lastly we wish to thank the Cameroon Government for financing this study.

Accepted for publication November 1986

REFERENCES

AKEREJOLA, O. O., SCHILLHORN VAN VEEN, T. W. & NJOKU, C. O. N. (1979). *Bulletin of Animal Health and Production in Africa*, **27**, 65–70.

ANDERSON, F. L. & CHRISTOFFERSON, P. V. (1973). *American Journal of Veterinary Research*, **34**, 1395–1398.

FABIYI, J. P. (1973). *Bulletin of Epizootic Diseases in Africa*, **21**, 277–286.

FAO (1966). Agricultural Development in Nigeria 1965–1980. p 220.

HERLICH, H. (1956). *Proceedings of the Helminthological Society of Washington,* **23,** 102–103.
HUNTER, A. R. & MACKENZIE, G. (1982). *Journal of Helminthology,* **56,** 135–144.
KUIL, H. (1973). Gastrointestinal nematodes in the Zaria area of Northern Nigeria. Mimeograph. Institute of Tropical Diseases, Utrecht and Department of Parasitology and Entomology, Ahmadu Bello University, Zaria.
SCHILLHORN VAN VEEN, T. J. (1981). *Bulletin of Animal Health and Production in Africa,* **29,** 279–283.
SCHILLHORN VAN VEEN, T. J. (1982). Proceedings of the 3rd International Conference on Goat Production and Diseases, Tusson, **2,** 85–89.
WILLIAMSON, G. & PAYNE, W. J. A. (1978). **An introduction to animal husbandry in the tropics.** The English Language Book Society and Longmans, London, p 43.

PRODUCTIVITE DES MOUTONS ET DES CHEVRES DANS TROIS SYSTEMES D'ELEVAGE A BAMENDA PROVINCE NORD-OUEST DU CAMEROUN

Résumé—La productivité des moutons et des chèvres a été examinée dans trois systèmes d'élevage. Un régime de droguage dans lequel chaque animal reçoit 5 doses de fenbendazole au cours d'une année donne des résultats similaires, en termes de survie et de gain de poids, au droguage mensuel. Les moutons d'élevage traditionnel sans traitement anthelmintique ont une survie et une croissance inférieures aux chèvres. Au contraire, ces derniéres en élevage traditionnel ont une meilleure croissance et produisent plus de petits bien, qu'en général, elles soient plus légères que les moutons.

PRODUCTIVIDAD DE OVEJAS Y CABRAS BAJO TRES SISTEMAS DE MANEJO EN BAMENDA, N.W. PROVINCIA DE CAMERUN

Resumen—Se estudió la productividad de ovejas y cabras bajo tres sistemas de manejo. Los resultados fueron similares, cuando se compararon dos regímenes de desparasitación con fenbendazole. En el primero, cada animal recibió cinco dosis en un año y en el segundo una dosis mensual. La sobrevivencia y aumento de peso vivo fueron similares en ambos grupos tratados y superiores a aquellos de animales controles. En estos últimos, las ovejas bajo sistema de manejo tradicional y sin tratamiento antiparasitario sobrevivieron y aumentaron de peso menos que las cabras. Estas crecieron y produjeron más crías, bajo manejo tradicional, a pesar de que fueron más livianas que las ovejas.